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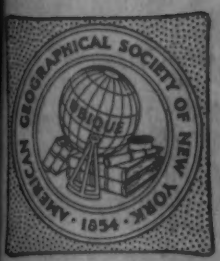

OCTOBER
1931

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Separate Maps published in the *Geographical Review* and the *Bulletin of the American Geographical Society*, the majority in color. 25 cents each. A list will be sent upon request.

THE
GEOGRAPHICAL REVIEW

VOL. XXI OCTOBER, 1931 NO. 4

THE VATICAN CITY STATE
FROM THE STANDPOINT OF POLITICAL GEOGRAPHY

Umberto Toschi
Royal Commercial Institute, Bologna

ON June 7, 1929, the Lateran Treaty between the Holy See and Italy was perfected by the exchange of ratifications, and a new state was brought into existence—the Vatican City State. Many essays have been published, in Italy and abroad, on the juridical features of the new body;[1] but there has as yet been no discussion of the state from the standpoint of political geography, singularly interesting as it is.

STATUS PRIOR TO THE LATERAN TREATY

As far as International Law is concerned, the Vatican City State came into existence only at the above-mentioned date, and as a consequence of the treaty ("creandosi per tal modo la Città del Vaticano"—Art. 3). However, within the boundaries of the Apostolic Palaces, the Vatican Gardens, and St. Peter's Church no authority had been enforced since September 20, 1870, but that of the Holy Father, or, *sede vacante*, of the Sacred College of Cardinals. Nobody in the character of an official of the Kingdom of Italy penetrated within those boundaries. The Law of Guarantee of May 13, 1871, was meant to settle the relations between the Kingdom and the Holy See, but it was unilateral and was never acknowledged by the Church and never put into force beyond the historic Portone di Bronzo, guarded by the Swiss soldiers wearing the picturesque costume that, according to the tradition, Michelangelo himself had designed. Thus the Vatican had militarily guarded boundaries, and

[1] Mention may be made of C. G. Fenwick: New City of the Vatican, *Amer. Journ. of Internatl. Law*, 1929, pp. 371–374.

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FIG. 1—Reproduction on a reduced scale (approximately 1 : 9000) of the official map of the Vatican City State with the signatures of Cardinal Gasparri and Signor Mussolini.

its own armed bodies fulfilled the police service inside. Italian census officials did not enter the Vatican; the Holy Father received ambassadors and sent them abroad; during the Great War he gave passports to his own officials, which were tacitly taken as valid by the Italian authorities as well as by those of other states.

Before the Lateran Treaty there existed, therefore, in Rome a Vatican territory, although very small in area, in which the Italian state did not exercise a full and entire, i.e. true sovereign authority,

and in which, on the other hand, resided an authority that was acknowledged in many circumstances as a sovereign. It is sufficient to say that a separate political body, geographically individualized, even if juridically imperfect, existed there. Such a condition—as the head of the Italian government, Signor Mussolini, textually said in

FIG. 2—Aerial view of the Vatican City State. The white lines mark the boundaries—the dashed lines indicating the walled boundaries (compare Fig. 6), the dotted line, St. Peter's Square where there is no material barrier.

the House of Parliament—was the point of departure for the negotiations carried on to solve the so-called Roman Question.

This diminutive territory was what was left to the Holy See after the revolutions and wars between 1859 and 1870 (see Fig. 3). At the beginning of 1859 the States of the Church were still widespread in central Italy. The occupation of these territories by the Italian state since 1870 was politically disregarded by the Holy See, although from time to time the pope openly protested against the situation actually existing. The Lateran Treaty regularized the unique situation.

The Italian state acknowledged the creation of an independent and sovereign state within the boundaries of the Vatican, the Holy See renounced the territory it formerly possessed beyond these boundaries and acknowledged, too, that a new state was created under its sovereignty. By common consent it was called the Vatican City State (Stato della Città del Vaticano).

Territory and Citizenship

There can be no sovereignty without a territory, be it ever so small. The present Vatican State is not a principality of which the pope happens to be the prince but a minimum of territory necessary in order that sovereignty "may appear full, entire, and visible" (preamble to the Treaty). The first constitutive element of this state is territory, and the state itself is constituted for a function that transcends the organization of its territory and citizens: in this lies the absolute originality of the Vatican State compared with any other of past and contemporary history.

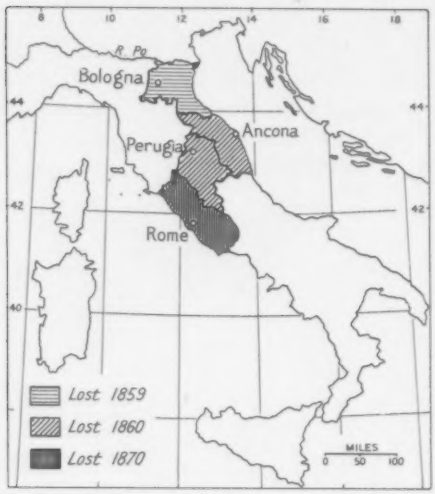


FIG. 3—Map showing the loss of the Papal states in central Italy from 1859 to 1870. Scale 1:16,000,000.

Such originality appears in a special light if we pass to consider, next to territory, the other constitutive element of a state, the citizens.

Vatican citizenship is not acquired either by sojourn or birth or choice. It belongs to those officials of the Holy See and members of their family supported by them who have taken up their residence inside the City, and also to cardinals residing in Rome.

Citizenship is obtained through a formal declaration of the papal authorities and is lost when the office with which it is connected ceases. In this case the former citizenship is resumed. For example the Swiss soldiers of the guard are Vatican citizens as long as they are serving; when they leave service they take again their Swiss citizenship. Citizens of another state are allowed to hold an office even inside the Vatican, keeping their residence outside and not changing their own citizenship; while there are inhabitants of the Vatican City that are not officials and therefore are not citizens, for example the pupils of the Ethiopian College.

Those who were born within the Vatican territory present a special case. They do not acquire Vatican citizenship *ipso jure* but only provided they take up their residence there and may be considered members of a family supported by a Vatican citizen. The moment when such conditions are modified those who were born in the Vatican territory take up the "original" citizenship, that is that of their parents.

Every other state is formed and exists in the first instance as an association of citizens aiming at the satisfaction of their common interests. Not even the so-called theocratic states, for example the Asiatic Lamaist societies or the Commonwealth of Mt. Athos, can be excepted. The Papal state, the Vatican City State of today, on the contrary, exists only as a means, an instrument for the attainment of purposes that go far beyond the small population shut up within its frontiers.

At the time of the creation of the state the citizens were 532 in number, and there were residing within its borders 250 persons not citizens. The movement of the population since then has been:

	Year 1929	Year 1930
Births	4	4
Deaths	2	10
Marriages	5	17

On January 1, 1931, the Vatican citizens were 639, divided according to their nationality—there can be no such thing as a Vatican nationality—as follows:

Italian	495	Dutch	2
Swiss	118	Native-born	2
French	8	Norwegian	1
German	8	Austrian	1
Spanish	3	Ethiopian	1

Adding 259 foreign citizens living in the City, we reach the total of 898 inhabitants.

Area and Boundaries

Let us examine now those characteristics of the state that more strictly pertain to the usual classification of political geography.

In the common classification, according to extent of territory, the Vatican City State with 108.7 acres must undoubtedly be placed among the very small states and is, no doubt, the smallest state in the world. Its area being nearly all taken up by buildings, streets, squares, and gardens, the Vatican City State, as its name expresses, is a state consisting of a city. But, unlike any other recorded by history, it is a city state that does not cover by itself a town area but is enclosed in a larger town area. Its boundaries are conspicuously marked throughout their length, being represented by strong walls built during the Middle Ages and in the Renaissance. An exception is made in St. Peter's Square (Piazza San Pietro) with the Bernini colonnade. This belongs to the new state, but its limits are not marked by any material barrier. The piazza is open to the public, and the Italian police authorities are intrusted with the police service on ordinary days as far as the atrium of the basilica. On the Holy Father's

FIG. 4—St. Peter's and the radio station of the Vatican City State.

demand the police authorities are bound to clear the piazza during ceremonies or visits of sovereigns. Then the Italian police force has to ensure order all round the piazza, where the Vatican corps serve. Owing to the small size of the state and the nature of its boundaries, the parties to the Lateran Treaty thought it advisable to take measures to ensure privacy, and certain of the buildings surrounding the Vatican City have been razed. The Italian state has also acknowledged in the Treaty that flights over the Vatican are forbidden, the whole territory of the Vatican City State being an "aeronautic prohibited area."

COMMUNICATIONS AND SERVICES

The Vatican City State is also a "closed state" as regards access to the sea. Its communications with foreign countries are made by a railway line that after a few yards leaves the territory and joins the Italian railways inside the city of Rome. It is agreed, however, that the Vatican may build its own airport, from where it will be possible for Vatican planes to fly to any other country. Similarly, while postal, telephonic, and telegraphic messages must be forwarded through Italian lines, the Vatican City possesses its own powerful wireless station by which it is possible to exchange messages with all parts of the world without depending on Italian offices.

Down to very recent times students and publicists on behalf of the Church had always claimed at least a band of territory reaching the sea as the only possible guarantee of full liberty and independence of communication between the Holy See and the rest of the world. The progress of wireless communication and air transport has offered a

FIG. 5—Railway station of the Vatican City State.

solution, impossible in former times, that meets both the national sensitiveness of Italy and the necessity affirmed by the Holy See. The Vatican City State has entered the Union Postale Universelle and the Union Télégraphique Universelle as well as Italy; it enjoys therefore all the rights embodied in the covenants of those unions.

The Vatican City State is a patrimonial state in the real meaning of the word. All real estate within its boundaries not only falls under the authority of the Holy See but is its full property.

On the other hand, instead of being divided according to a variety of functions, the whole territory is devoted to services of a public character, which, for the most part, go beyond the interests of its inhabitants and of the state itself. The subdivision of these services is illustrated in Figure 1.

FIG. 6—Walls of the Vatican City State, the chapel of Lourdes, and the astronomical observatory.

Entrance to the state (with the exception of St. Peter's Square, as stated above) is limited—as to persons and to time—to the decision of its authorities. At the appointed time in the evening the entrance to the city is closed, and nobody can stay within the territory but Vatican citizens or persons having special permission. In the morning the entrances are opened, and anybody may be admitted to the Vatican territory and walk nearly everywhere without a special permit.

As regards material existence the inhabitants of the Vatican City State are almost completely dependent on the outside. The Vatican State has no customs but receives food, industrial products, and water and gas from or through Italy. Only electric power is produced in the state by a central station. This station and the Vatican printing house are the only factories in the state, with the exception of the two school factories of tapestry and mosaics.

As all real property belongs to the Holy See the financial régime of the state is a quite special one. No imposts can be assessed, but taxes are levied corresponding to services. The main sources of state income are derived from the fees paid by the public for visiting

the art treasures. The state administration has recourse also to that income that flows to the Holy See in virtue of its being the supreme organ of the Catholic Church, viz. the voluntary offerings of its members (Peter's pence) from all over the world.

Extraterritorial Areas

Another interesting feature of the Vatican State is the number and extension of areas beyond its boundaries, in Italian territory,

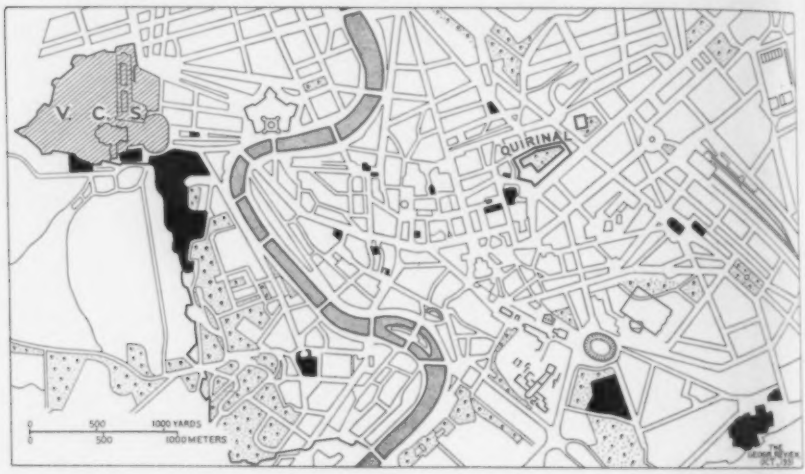


Fig. 7—Map showing, in black, the areas outside the Vatican City State over which extraterritorial rights are exercised. St. Paul's Church and dependencies, five kilometers distant, and the estates at Castelgandolfo above the Alban Lake, southeast of Rome, lie without the map.

on which it enjoys extraterritorial rights and therefore a very large and almost supreme authority. Italy has agreed to exempt these areas from taxes and from obedience to the law of expropriation for public utilities; papal authorities are entrusted with internal police service. As respects postal and telegraphic service they are considered to belong to the Vatican.

Such areas cover a surface of about 170 acres. The largest (nearly 100 acres) is formed by the Papal Palace, Villa and Palazzetto Cybo, and Villa Barberini at Castelgandolfo—a group of estates that was already acknowledged as a summer residence of the pope by the Guarantee Act of 1870. The second consists of Villa Gabrielli and its environs, on the Gianicolo Hill, whose entrance is quite near the Vatican City; it covers 35 acres and is reserved for the new buildings that may become necessary in the future. Between this and the Vatican there is still another small area with the Palace of the Holy Office.

The other areas are nearly all occupied by churches and palaces that have long been the seat of central offices of the Holy See (Lateran

Basilica with Missions Museum, St. Paul's, St. Mary Major's, St. Mary in Trastevere, Palaces of Dataria, Cancelleria, Propaganda Fide, Convertendi, Vicariate, St. Callistus'). Except the dependence of Castelgandolfo the most distant extraterritorial area is five kilometers from the Vatican (St. Paul's).

The problem of communications between the organs of the state and extraterritorial areas has been solved by allowing those persons or documents employed for official intercourse between the state and the extraterritorial zones to be provided with diplomatic guarantees.

A Neutral State

Italian is the official language of the state, but Latin remains the official language of the Holy See. Acta Apostolicae Sedis are still published in Latin, and there is a supplement in Italian, containing the acts and regulations affecting the Vatican City State. There is, nevertheless, a great liberty in the use of language, as is shown by the texts of concordats that are in one or two different languages. Among the more recent ones, the concordat with Rumania is in French; the one with Portugal is in Portuguese; the one with Prussia is in Latin and German.

The Vatican City State is a neutral state. The Holy See, as such and also as being invested with a territorial sovereignty, "will remain outside the temporal rivalries among the other states and also apart from international meetings called for such purposes" except in case the parties to a conflict should unanimously appeal to its mission of peace. It follows that the Holy See can never be a member of the League of Nations, as this is an organ that deals with the political arrangement of states.

However, this clause does not prevent the Vatican City State or the Holy See from attending the international meetings that any state or organization (be it the League of Nations) may arrange for other purposes than temporal "competition" or "rivalries." When the Holy See is attending any of those meetings it may either appear in the two capacities of supreme authority of the Church and of the Sovereign of Vatican City State or may act in one of them only. That is why the Vatican City State could adhere to the conventions of the post and telegraph unions and also why it will always be possible for the Holy See to take a part in the international organization of relief in case of calamities, as was done in 1921 for the victims of the Russian famine.

The Holy See has engaged not to put its spiritual authority at the service of any state that is at conflict with another and not to allow the territory on which it has a sovereignty to be used for any step directed to the help of a particular state.

The Italian state has engaged to consider the Vatican City State "always and in any case as a neutral and inviolable territory." Precisely on account of these conditions the Vatican City State differs from all the states that in common classification are termed very small or diminutive states. Its independence is greater by far than that of either the Principality of Monaco or Andorra or San Marino; the subjection of the latter to other states is only tempered by forms of "alliance" or "protection." Signor Mussolini rightly said that "nowadays the Vatican is not less far from the Quirinal than are Paris, Madrid, or Warsaw."

The Geographical Basis

In conclusion we may refer to the geographical basis on which the historical development and present rôle of both the state and the seat of the Papacy rest. This basis is their position in Rome, as has been acknowledged by all students of political geography from Ratzel to Brunhes and to Vaughan Cornish. The advantages of the position of Rome in the midst of the Mediterranean Sea—the best climatic zone of the Ancient World, that cradle of occidental civilization—did not pass away when the Roman Empire was overthrown. Ancient as well as medieval peoples were aware that Rome had given its name and a spiritual heritage to the civilized world. That rôle taken up by the Church has in the process of time gradually been divested of its immediate political meaning while it has kept pace with the expansion of European policy and spirit.

According to the Catholic Directory, London, the Roman Catholic population of the world is reckoned at 334,665,000 souls, of whom 18,605,000 are in the United States and 16,072,000 in the British Commonwealth (4,070,000 in British America). To conclude, in the terms of a modern school of geographers, it may be said that the geopolitical importance of the Vatican City State is greater by far than that of other small states, and it may be added that the historical making of this importance is mostly based on its position in the oecumene, i.e. on a primarily geographical factor.

SETTLEMENT ZONES OF THE SIERRA NEVADA DE SANTA MARTA, COLOMBIA*

Griffith Taylor

University of Chicago

FIG. 1—The Sierra Nev da de Santa Marta, Colombia. Scale 1 : 20,000,000.

IN few parts of the world are to be found mountains rising 17,000 feet above a coast; and when this occurs in a tropical latitude as is the case with the Sierra Nevada de Santa Marta of Colombia, whose snowy crest is only 23 miles from a tropical sea, a very special environment results. On the slopes of the Nevadas behind the town of Santa Marta there is a mantle of tropical jungle flung over the entire slope almost from sea level up to 10,000 feet. Above the jungle is a zone of grasslands, páramos, while the uppermost zone is capped with eternal snow which feeds a few small glaciers. The entire series is visible from the Caribbean, and nowhere in the world is an exact parallel to be found. Perhaps at Mt. Carstens in Dutch New Guinea is the closest approximation. Elsewhere we encounter along the coast lands a broad belt of arid country, or the snow line is too far from the coast, or the country is not hot enough for all the above characteristics to be present in one environment.

The granitic massif of the Sierra Nevada, in plan, is a triangular block in which each side is about 75 miles long (see Fig. 1). It rises to a height of 19,000 feet at the northwest corner above Santa Marta. It is completely isolated from the Andean mountains; for the divide between the Rio Cesar (a tributary of the Magdalena on the southeast) and the Rio Rancheria (which flows into the sea on the northeast) is only about 400 feet above the sea. The massif has its steepest face on the north and northwest (see Fig. 2). It slopes much more gently to the southeast, so that almost all its communications are from the vicinity of Valle de Upar. The latter in turn is in touch with

*I wish to acknowledge the help of Mr. Raye R. Platt of the American Geographical Society of New York; Mr. Victor M. Cutter, President of the United Fruit Company, for valuable climatic and economic data and for my hospitable reception in Colombia; Messrs. T. D. Cabot and P. J. Darlington, for advice and data regarding the upper zones in the Nevadas; and Dr. Paul C. Standley, for naming a number of Colombian plants. In Colombia I am indebted to Mr. Fletcher Hatch, Mr. Opryshek, Mr. Flye and his two sons, and Mr. A. G. Infante.

the towns on the Magdalena far to the southwest and is almost cut off by the absence of a feasible road from the flourishing region of Santa Marta, which at first glance would appear to be its natural outlet.

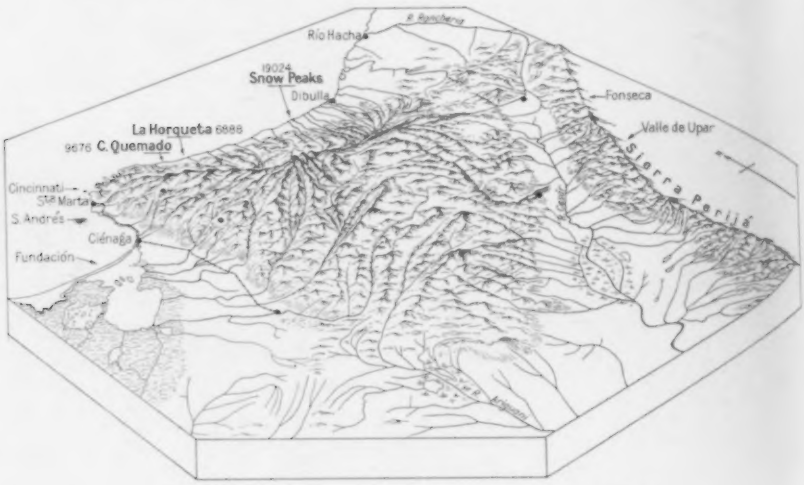


FIG. 2—Block diagram of the Sierra Nevada de Santa Marta.

The Sierra Nevada de Santa Marta is a resistant block of granite—part, perhaps, of an Antillean continent that foundered during the Tertiary period (compare W. Sievers: Die Sierra Nevada de Santa Marta und die Sierra de Perijá, *Zeitschr. Gesell. für Erdkunde zu Berlin*, Vol. 23, 1888, pp. 1–158). Probably it was land during the Mesozoic period and was surrounded by seas in which extensive sedimentation occurred. During Tertiary times folding occurred both to southwest and southeast, and this buckling gave rise to the Cordillera Central and Cordillera Oriental of Colombia. The ancient granite massif of the Nevada was also elevated, but *en masse* as a fault block. The evidence of Stille and others seems to show that the Magdalena River just to the west occupies a *graben*, while the Maracaibo Gulf just to the east is possibly a similar *graben* not yet filled with sediments.

There seem to be no rock structures in this uniform granite massif that would determine such larger valleys as those of the Rio Frio. The dissection is very marked, and the plateau is by no means in its original pre-uplift condition, for it is scarred by juvenile valleys. My own impression is that the fault block was tilted on elevation—the slope being directed to the southeast—and that secondary faults probably determined the direction of the three or four larger rivers. In my traverse up the Rio Frio divide I crossed an area that is blank on Sievers' geological map. Only rarely did rock show, save at the beginning and end of the traverse. All the rock seen was gneissic granite or closely allied.

There is no traffic between the plateau and the coast towns. I learned of an Indian trail that leads up from Dibulla on the north coast to the plateau, but I know of only one explorer who has used it—De Brettes, who returned by this route from a trip to what he believed the summit (5887 meters) in 1891.[1] My own traverse was

[1] Joseph de Brettes: Chez les Indiens du nord de la Colombie, *Le Tour du Monde*, Vol. 4 (N. S.), 1898, pp. 61–96 and 433–480.

along the other Indian trail from Rio Frio up to San Sebastian. Here again I could learn of no one who had made the whole journey except a Colombian priest many years ago.

FIG. 3—View of the western part of Santa Marta, looking south from Quarry Hill. The central white building is next the Commissariat of the United Fruit Company (U. F. C. on Fig. 4). Notice the cactus in the foreground, with laborer's "barracks" just behind.

THE PATTERN OF THE TOWN OF SANTA MARTA

The foundation of the town of Santa Marta dates back to July 29, 1525, when Rodriguez de Bastidas landed with a large number of settlers on the shore of Santa Marta Bay, a name given in honor of the patron saint of that day. A recent "History of the Province of Santa Marta," by E. R. Tirado,[2] reproduces an early chart of the town presumably as it appeared a few decades later, where the sheltered harbor and its light and fort are shown. The plaza and six of the present rectangular streets were already laid out, and there was a church somewhere in the vicinity of the present convent church in the southeast of the town (see Fig. 4).

The town owes its early start, no doubt, largely to the fact that it lies precisely where the trade winds would bring the Spanish navigators most readily from their early settlements in Santo Domingo (1493) to the mainland. Here a long rocky spur of the Nevadas, known as the San Lorenzo Range, reaches the sea in a series of rocky capes (Fig. 2), to the southwest end of which lies a beautiful sheltered bay. The Manzanares River has deposited an alluvial plain at the head of the bay, and this is the site of the city of Santa Marta. The level land extends east about ten miles to Bonda, but hills rise sharply

[2] E. R. Tirado: Historia de la Provincia de Santa Marta, Seville, 1929. Ojeda built a fortress near Santa Marta in 1501 or 1502; probably antedating Columbus at Nombre de Dios.

north and south of the plain. It is remarkable that no advantage is taken of these elevated sites. The town, sheltered from the trade wind in part, is muggy and hot. It is very dusty in the frequent dry spells, yet no roads have been built up the surrounding hills, not even to the coffee haciendas, some 18 miles to the east and still reached only by mule tracks.

The river enters at the shallow south end of the bay (Fig. 4). Under the northern headland there is deep water. Here the largest boats in the fruit trade can berth easily alongside the shore, and the railway is only a stone's throw from the ships. It is not difficult to distinguish that part of the town which is purely Latin American from that which has developed mainly as the result of the recent commercial growth of Santa Marta. The rectangular plan and the narrow streets date far back, as we have said. There are four types of buildings which together constitute practically the whole of the town. These are arranged in fairly definite zones plotted in some detail in Fig. 4. The foreign business is chiefly in the west, and the local business in the center. The poorer people live chiefly in the east. The characters of the buildings are shown in Figures 5, 6, and 8. One-story buildings prevail save in the west of the town. A few of the larger public or private buildings have three stories. Santa Marta is the capital of the large department of Magdalena, and some of its official buildings are pleasing in appearance. More elaborate private residences have fairly recently been erected in the southwest of the town. These are often surrounded with a small garden and illustrate the adoption of a type of house more like those of the northern peoples. Many such homes fringe the one modern avenue in Santa Marta—that leading eastward to San Pedro.

North of the town is a salty plain occupied in part by a shallow playa (Fig. 4). Salt works were formerly in operation here. On this plain has risen a barrack-like suburb largely inhabited by laborers on the wharves. Very different is the suburb south of the city, where under beautiful poinciana and acacia trees are the bungalows of the United Fruit Company.

The Banana Industry and Its Effects

In early colonial days Santa Marta was practically abandoned, except as a penal colony, for there was no gold in the vicinity and agriculture was confined to the growing of a little fruit for local use. In 1882, when the construction of the Santa Marta railroad was begun, the city had a population of only a few thousands. In fact it had fallen into so parlous a state that fine old colonial mansions were being torn down and the materials transported to Barranquilla, which had begun to assume some importance as a port of entry.

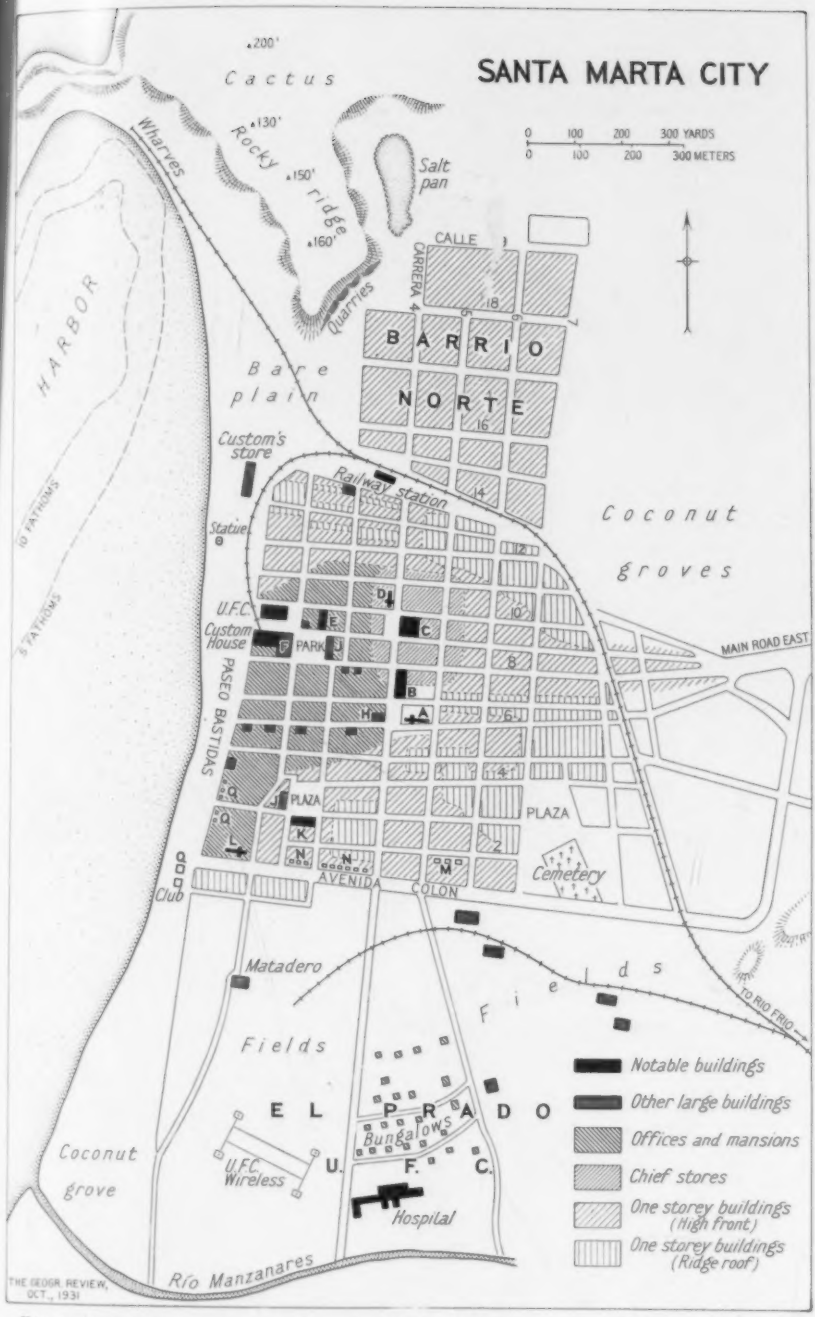


FIG. 4—Map of the city of Santa Marta based on the city plan, 1929. Reference: A, cathedral; B, municipal palace; C, market; D, church of San Francisco; E, governor's palace; F, cuartel; H, bishop's palace; J, schools; K, law courts; L, hospital; M, N, Q, quintas. El Prado is the suburb of the United Fruit Co.

FIG. 5

FIG. 6

FIG. 7

FIG. 5—Typical street in the poorer section in the east of Santa Marta, looking west down Calle 7 to the cathedral. Note the Spanish "sitting windows" and the narrow sidewalks.

FIG. 6—Residences of wealthier citizens in Calle 2, looking west.

FIG. 7—Typical houses built of planks in the little "banana town" of Rio Frio.

With the exception of a little tobacco, cacao, and cane for the local manufacture of rum, the acres now given over to banana culture were virgin forest, practically uninhabited. The only industry, if it can be called industry, was a little lumbering around the rivers, the timber being floated down and across the Ciénaga Grande to Barranquilla for local construction purposes. Dwellings could be had in the city, rent free, for care of the building, and labor—when there was any employment—was paid from twenty to forty cents a day. Now Santa Marta is the scene of one of the most successful experiments in tropical agriculture. Until the beginning of this century the banana industry in tropical America was carried on unsystematically and inefficiently. Methods of cultivation were very primitive and were almost wholly in the hands of native planters. But North American enterprise changed all this. The United Fruit Company was founded in 1899 with headquarters at Boston. It has succeeded in changing the banana from a luxury to a staple food of millions in the temperate zone.

FIG. 8—Better-class houses in Calle 4, looking east. Two-story buildings are relatively rare. The corner building is a small store, almost universal in this position.

The company has gradually extended its plantations to the south of Santa Marta until it has here 27,000 acres of bananas. Here the whole basis of agriculture has been changed, for the peasant can now obtain steady work and steady wages. Dock workers may receive as much as $90 a week! Furthermore, this enterprise has encouraged private activities—for the fleet of the company is also available for the prompt marketing of fruit from 33,000 acres owned by Colombians in the plains below the Sierra Nevada. The 58-mile railway from Santa Marta to Fundación, the sole means of transport in the district, is owned by the company.

The operation of the United Fruit Company in this district has brought wealth to the republic. Previous to its coming in 1901 a few bananas had been grown in the district, but no regular shipments were made. An English company had built a narrow-gauge railroad which did not pay running expenses. Santa Marta had a population of about 6000. The town of Ciénaga consisted of a few fishing shacks.

In the company's first year the total shipments of bananas amounted to 284,000 stems. In 1930 over 11,000,000 stems were exported, and within the last ten years a total of nearly 92,000,000 stems have been shipped. Last year in Colombia the United Fruit Company spent for wages and fruit more than $7,500,000, this amount actually going to the nationals of Colombia. Santa Marta has grown to be a city of 30,000 inhabitants, and Ciénaga has 40,000.

Rainfall and Temperature of Santa Marta Lowlands[3]

The banana region is sheltered from the dominant northeast trade wind by the Sierra Nevada, so that the rainfall is rather low for latitude 11° N. The temperature is high (annual average 81° F.) and varies little from month to month, but there is a marked diurnal range. The average weekly maximum throughout 1930 varied from 90° or 91° (February and October) to 96° (March and September). The weekly minimum in 1930 varied from 68° (January, February, and March) to 74° (September, October, November, and December).

During seven months of the year—the wet season, from May through November—the rainfall is fairly uniform, and the average total amounts to 43 inches. During the other five months of the year there is no rainfall, and continuous irrigation of the banana plantations is necessary. The following are the figures (inches of rain) for the last eleven years:

1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930
24	40	38	21	77	37	51	65	49	44	29

The extraordinary difference in the rainfall owing to an elevation of only one or two thousand feet is clearly indicated by the change from the xerophytic vegetation of the lowlands to the dense jungle of the northwestern slope. This is described in later sections of this paper. The constant clouds that mask the highlands must greatly reduce evaporation—so that perhaps the rainfall is not as great in the higher levels as would otherwise be necessary to maintain the luxuriant plant life.

Through the Banana Belt

The rocky hills around Santa Marta are clothed in cactus of many varieties, and there are also many thorny trees, forming a sort of chaparral. On the railway from Santa Marta to Ciénaga these types dominate the landscape. Here and there are clearings with some grass where cattle are pastured. Where a stream is crossed (as near Gaira) some small banana plantations are to be found. At the Toribia River there are large banana plantations belonging to local Colombians.

[3] Notes on the climate are based on data kindly supplied by Mr. Victor M. Cutter, President of the United Fruit Company.

Ciénaga has a somewhat larger population than Santa Marta. It is an airport of the "Scadta," and planes fly regularly to and from Barranquilla on the Magdalena River. There is a good deal of traffic by small boats, which can reach the Magdalena by way of the Ciénaga

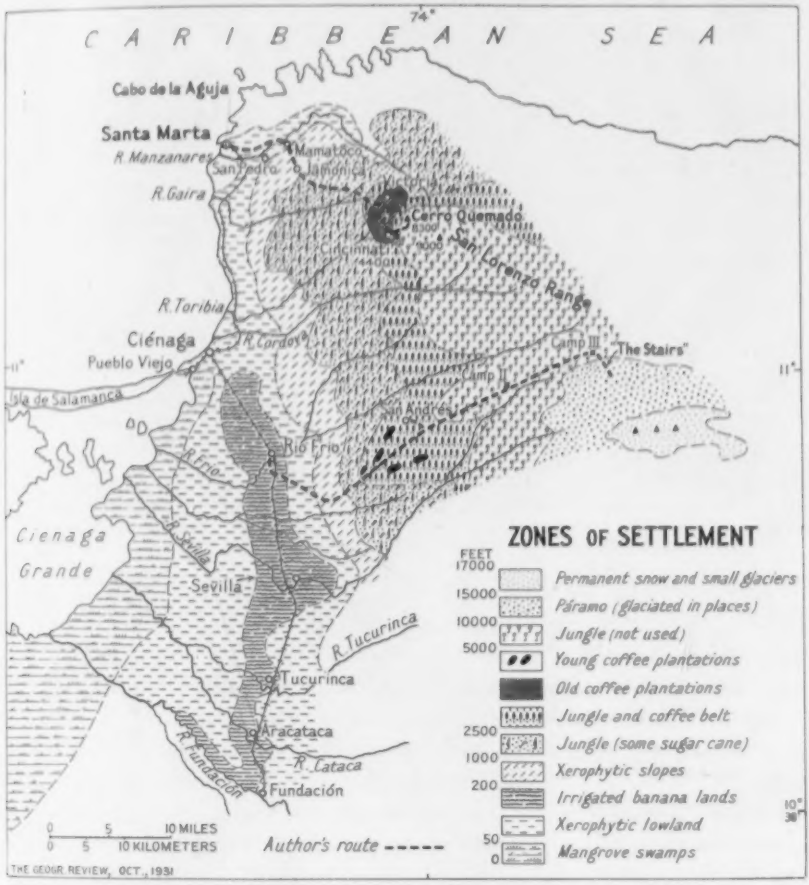


FIG. 9—Sketch map of zones of settlement on the northwestern slopes of the Sierra Nevada de Santa Marta. Scale 1 : 925,000. Compare Figure 2 and Table I.

Grande. From Ciénaga to Fundación the railway runs through banana plantations almost the whole way (Fig. 9). Beyond Fundación there is little permanent water and hardly any settlement for fifty miles, until the town of Valle de Upar is reached on the southeastern slope of the Nevadas.

All the many thousand of acres of bananas in the region have the same appearance. The plants are about twelve feet high and grow in rows with shallow trenches between. Numerous canals and sluices link these with the rivers—which in turn are supplied by the frequent rains of the jungle belt and by the melting of the snows above 15,000

feet. Nothing is more striking than to step from the dark, damp soil under the bananas directly onto the arid, sandy soil with the xerophytic vegetation of unirrigated land. Banana cutting goes on almost continuously throughout the region. The fruit is transferred in bullock carts to the railway and thence to the wharf at Santa Marta. From Santa Marta most of the fruit goes to New York, but a British subsidiary line takes large cargoes to England, and a number of European steamers also take bananas to the Continent.

FIG. 10—Sketch survey of the "banana town" of Rio Frio, 23 miles south of Santa Marta.

The writer made a survey of the little town of Rio Frio which represents fairly a town depending almost entirely on the banana industry (Fig. 10). It has grown up about half a mile to the north of the river after which it is named. Simons[4] records that it started in 1875 as a center of tobacco growing and in 1881 had 1000 inhabitants. In 1930 it contained about 500 houses and, as I estimated, about 2000 inhabitants. I saw no tobacco, but the whole town was closely surrounded by banana plantations. There were patches of bananas growing among the houses, and I was informed that house room could only be obtained by "nibbling out" a space from the encroaching bananas. Apart from a few pineapples, the only crop other than bananas appeared to be a field of yuca (a sort of yam) in the extreme southeast of the town.

A Traverse of the Tropical Jungle up to 5000 Feet

The area which I traversed from Rio Frio eastward up the slopes of the plateau appears as a blank space on Sievers' map of the Sierra Nevada. Never have I attempted to survey such difficult country. Hardly any cross bearings were possible owing to the jungle and dense clouds after the first few hours, and it was impossible to obtain a view of the summit peaks at the end of my traverse. Hence the position and elevation of the locality known as "The Stairs" (Fig.

[4] F. A. A. Simons: On the Sierra Nevada of Santa Marta and Its Watershed, *Proc. Royal Geogr. Soc.*, Vol. 3 (N. S.) 1881, pp. 705–723.

9) can only be approximately correct. The whole traverse is based on dead reckoning.

I started from Rio Frio at 6 a. m. one morning in December, 1930. Food and blankets were packed on a burro, which was driven by a Colombian peon called Luis. In about an hour we reached the rocky

FIG. 11—The Rio Sevilla at Sevilla, the center of the United Fruit Company's banana plantations. Colombian women washing clothes. The river is low after a very dry season. Slopes of the Sierra Nevada in the background.

lower slopes of the Nevada massif. The trail is used a good deal as far as the Indian village of San Andrés. At first it rises fairly rapidly over gneissic outcrops. In the steep juvenile valleys, below the ridge we were ascending, the tropical jungle reached down well below 1000 feet; but on the ridge itself, with its poor sandy soil, thorny scrub and cactus accompanied us up to about 1200 feet above sea level. The trail led to the east or northeast almost the whole of the journey until we reached "The Stairs." The steepest section was between the 1000 and 2000-foot contours. The most striking trees were deciduous "bottle trees" with swollen trunks three feet across rapidly tapering to one foot. They carried large white flowers with long stamens. Luis gave them the name of "Ma-agua," and they were about 30 feet in height (see also Table I).

At 1500 feet we entered a narrow belt of grassland—due, as I understand it, to burning off by Colombian cattlemen. The tough blady grass did not have a very nutritious appearance, but we passed several corrals and one or two *vaqueros* who lived in small houses on adjacent ridges below the trail. We were now well into the real jungle, which surrounded the grassland on all sides. Adjoining the few humble dwellings were patches of sugar cane and some papaya trees. Hereabouts was the sole water, close to the trail, at a ferny

FIG. 12

FIG. 13

FIG. 14

FIG. 12—The three leading Indians of San Andrés. Each man holds a small gourd (*poporo*) of lime for use with coca.

FIG. 13—Adult Arawak Indian (4′ 7″) and boy with his carrier ox on the trail below San Andrés.

FIG. 14—The water-bearing Bromelia (*Tillandsia*), common in the jungle from 6000 feet up to 9000 feet. The hat is on the flower spike.

gulley at the foot of the grassland. It is known as the Quebrada de Boya. Here a Colombian lad with another burro joined us.

We continued to the northeast, soon leaving the grassland, which was only a mile or so in length. Here was the largest tree I saw in the jungle. It was nearly ten feet in diameter, and Luis called it "caracole." The surface was a wet, heavy clay from now on. It surprised me that gneiss and granite should give rise to such a soil, but probably a great amount of humus was included. Nine-tenths of the journey was along a narrow divide with gorges a thousand feet deep or more on each side. In spite of this ready drainage the trail was covered with deep mud in many places, and often it traversed pools of water. Probably the dense vegetation and tangle of roots prevented any local drainage of the actual divide, in spite of its often being but a few feet wide. There was no noteworthy rainfall during the whole of our journey, though we were often enveloped in the clouds in the higher regions.

At 2500 feet we reached a region marked by plentiful bracken and also by smaller, delicate ferns. Here *platanillo*, a plant akin to the banana, was abundant. Shortly after noon we came to the first small clearing, where coffee and beans had been planted along the northern slope of the divide (Fig. 9). In a long strip, leading from the ridge down to the river on the south, there was a plantation of

sugar cane. The trail was now very steep for several hundred feet and led us up to a fair-sized hacienda, built of adobe, at about 3500 feet. Here a citizen of Ciénaga had a country residence, surrounded by ten hectares of coffee. Proceeding along the ridge, now much more level, we passed a number of smaller coffee plantations. They all seemed to be in the early stages of development. Some sugar cane and a few bananas grew with the coffee.

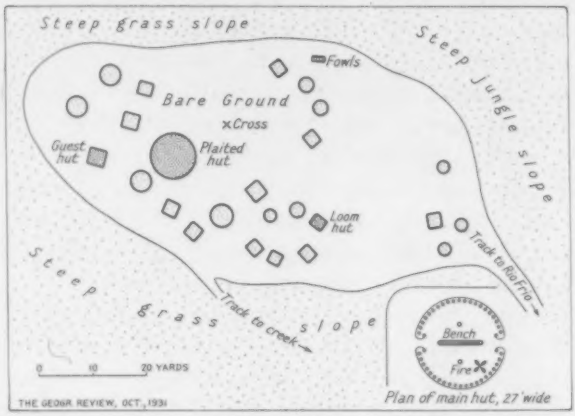


FIG. 15—Plan of the Indian village of San Andrés on the northwestern slopes of the Sierra Nevada de Santa Marta. Compare Figure 9.

Above 4000 feet the trail was so steep that we had to haul the burros up the slope. The jungle was very dense, and it was almost impossible to leave the narrow trail. We slowly reached 5000 feet and now approached the Indian village. We passed the trail to the last coffee plantation, where our companion left us; and gradually the trail turned to the north and then dipped steeply into the valley of the Rio Frio. Descending some 500 feet we arrived at a grassy spur on which were clustered some huts, dominated by a wooden cross.

THE INDIAN VILLAGE OF SAN ANDRÉS

This aboriginal settlement has not changed much in culture from pre-Conquest days. The huts are arranged in no particular order so far as I could learn (Fig. 15). Of the two dozen that compose the village, half are circular in plan and half are square. They vary from 15 feet to 27 feet in diameter and are about 20 feet high. The walls are made of lumps of mud, some eight inches across, held together by a loose framework of thin laths. The roofs are made of palm thatch and culminate in a central point or in a flat ridge with projecting ends, or sometimes in a very short ridge with two short poles. In some cases a buttress of mud surrounds the hut like a parapet. The doors are solid slabs of wood with projecting tenons which fit into holes in the sills—thus primitive hinges are constructed. The largest hut, however, has walls made of plaited cane strips.

There is little in the hut except a bench or stools each carved out

of a solid log, each with four short square legs. I saw only one pot in the village, though there were plenty of calabashes and many dishes and spoons made therefrom. A number of hammocks are suspended from the roof, together with string shoulder bags (*machila*), of which each native usually carries one or two. A native loom, of a type that Professor F. C. Cole informs me is found from the Southwest of the United States well into South America, is the most elaborate article in the village. Its frame is square, about five feet each way. A bag of crude cotton hung near by in the hut. From this an Indian plucked a tuft and rapidly twisted it into thread. He used a wooden spindle a foot long, carrying a small wooden flywheel. This was whirled rapidly with the right hand—by rolling it on his bare thigh. With the left hand he fed the spindle with cotton from the tuft. The yarn thus formed was the basis of the weaving. Their clothes were all woven on the native loom.

The senior men of the village wore short, loose trousers. Some men wore woven headbands, while the women used broad-fringed belts. The men were about 4 feet 7 inches tall, and the women 4 feet 5 inches. These peaceful Indians belong to the Arawak stock; and these, as is well known, are of very short stature. I was told that there were about 30 men, 30 women, and 20 children in the community.

Early in the morning the women and children go down to their plantations in the valley of the Rio Frio. Here they cultivate bananas, beans, and malangas. There are a few fowls in the village, and some of the large oxen which the Indians bring down from the páramo, graze around the huts. Many people in Santa Marta warned me that the Indians would do nothing for me in the way of food, lodging, or guidance. They were said to be suspicious and doped with coca; only rum would render them courteous and helpful. It is perhaps worth noting that I found this quite incorrect. I offered them payment in small coins from a bagful of nickels which I kept much in evidence, and in a short time I was on the friendliest terms with all the men and children and was even able to get photographs of the women after a little persuasion. It is true, however, that each man carried his gourd of lime (made from ground sea shells) and was continually chewing coca leaves. When we returned they hospitably swept out a hut and brought us many gifts of fruit and food.

The huts, food, clothes, and language remain much in their primitive form. But there were several shotguns in the village and a Spanish ax or two. The oxen, of course, date only from Spanish days. One man could read Spanish, while many could speak a little. I wrote down a short Arawak vocabulary, of which the ten numbers are as follows: (1) é-zo, (2) máu-djua, (3) mái-kua, (4) m'kí-u, (5) a-chi-ua, (6) tai-djúa-a, (7) kú-gua, (8) a-lí-gua, (9) é-ta-gua, (10) u-gúa.

The Indians at 4400 feet elevation are being encroached upon

by the Colombian settlers, one of whom is only a few miles west at about the same level. It seems clear that they must in the near future give way to or be absorbed by the more complex culture approaching them from the lowlands. There would, however, appear to be unlimited space at their disposal in the Indian Reservation to the east, for I believe there is no other Indian village until San Sebastian on the páramo is reached. This is a week's journey, or more, through very rough country.

Traverse of the Jungle, 5000 to 10,000 Feet

Leaving San Andrés early in the morning we branched off the Rio Frio trail less than half a mile to the east. The climb to 5000 feet was very steep, the divide very narrow with deep gorges on either side, but the jungle was so dense that one could see only a short distance in any direction. We here reached the habitat of the most characteristic plant in this jungle—the water-bearing *Tillandsia*, which collects the rain in its large sword-like leaf bases.[5] Almost every tree carried epiphytic plants, of which this was the largest kind. Tree ferns and dense sphagnum-like moss (*Lycopodium* sp.) were also abundant below the trees in the dense jungle.

Every five miles or so there is a clearing of half an acre in the jungle, with a rough open shed built by the Indians. We found the first near 5500 feet and a smaller one, where we camped later. A few miles beyond this locality was a much larger shed surrounded by a close growth of mint. The divide increased in elevation but slowly from 5500 to 6500 and led us to the northeast most of the day. Unfortunately, clouds covered most of the mountains, but from near the 7000-foot contour I obtained a view of a high range to the east and east-northeast. The farther portion of this range seemed to be covered with snow on its northern face, but we soon lost our view in the thick clouds.

A few miles farther on, from near the 7500-foot contour, I gained a better view of nearer mountains southeast and east-southeast. They appeared to be less than five miles away, for I could identify single trees on their lower slopes quite clearly. There were some striking dark "horns" of rock, which appeared to be over 100 feet high, near the top of this range; and definite grasslands, páramos, were visible to the east-southeast high up on the slopes.

As we approached the 8000-foot contour the jungle for a time became more open along the ridge. Here we found the *Tillandsia* or a close relative growing from a stem in the ground. Hereabouts blackberry vines were abundant. After a mile or less we entered a

[5] I made a collection of 30 typical plants on this traverse. These have kindly been identified by Dr. Paul C. Standley of the Field Museum, Chicago.

FIG. 16—Glacial tarn and plucked platform at about 12,500 feet, just south of "The Stairs." (Drawn from a photograph by P. J. Darlington.)

thick maze of bamboo canes each about an inch in diameter. Some of these contained water, and we were glad of it, for we had had no water that day except from *Tillandsia* or bamboo. A shrub about six feet high (*Lisianthus*), with a large pink "trumpet" flower, was very common at about 8500 feet.

A mile or two farther we reached the end of the long divide and were faced by a series of steep pyramidal crags, known as "The Stairs," up which it was hard to scramble. The burro refused to try, and I therefore left Luis behind and climbed up several hundred feet alone. I was now above the jungle in a grassy environment brightened by large blue lupines. This species of *Lupinus* is allied to *pubescens*, but Dr. Standley thinks it may be a new species. Associated with the lupines were ferns like *Lomaria*, dwarf bamboo, various heaths, berry plants, and other less familiar plants resembling cycads. Dense clouds enveloped me, and at times I could hardly make out the vestiges of a track. Yet it was clear that somehow the Indians get their oxen over these crags to the adjacent páramo. I decided to finish my reconnaissance at this point, which was about 10,000 feet above sea level.

As regards the páramos above 10,000 feet, I may quote Simons, who is, however, speaking of the region above San Sebastian, in the upper valley of the Fundación: "The Indians feed large herds of cattle and sheep on the rich pastures of the Nevada, but do not attend to them, so they run completely wild, and are for commercial purposes totally lost."[6] The whole Nevada region above the tree line is part of a reservation for the Indians and is not inhabited by Colombians.

THE PÁRAMO AND THE SNOW LINE

I owe to Mr. T. D. Cabot[7] and Mr. P. J. Darlington, who made the ascent by the same track as myself but reached a little higher altitude, some interesting notes on the region above the tree line. Glacial tarns and beautifully preserved lateral moraines occur at about 12,000 feet elevation,[8] just to the east of "The Stairs" and on

[6] Simons, *op. cit.*, p. 707.

[7] See also T. D. Cabot: Mountains of the Caribbean, *Appalachia*, Vol. 18, No. 1, 1930, pp. 17–22.

[8] The descent of the snow line during the Pleistocene Ice Ages and its effect on the topography of a number of southern lands is discussed in the writer's recent book, "Antarctic Adventure and Research," New York, 1930, pp. 131–135.

the slopes of the high ridge described earlier. They are clearly shown in Mr. Darlington's photographs; and I have given sketches of them in Figures 16 and 17.

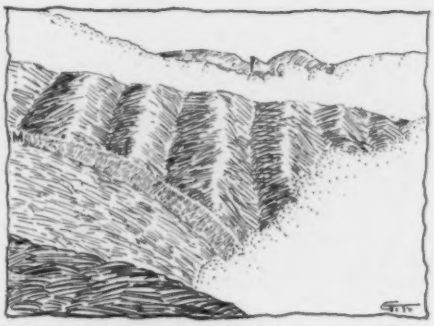


FIG. 17—A lateral moraine (M) on the páramo at about 12,000 feet; just south of "The Stairs." (Drawn from a photograph by P. J. Darlington.)

Although I was not able to reach the snow line, I was able to observe and sketch it from the San Lorenzo Range a week later. Sievers and Simons both approached the summit from San Sebastian by way of the undulating plateau to the south of the peak. Sievers found moraines and similar evidence of glaciation in the upper Cataca valleys at 11,800 feet (3600 meters). He quotes 15,400 feet as the permanent snow line on the south, but it is probably considerably lower on the shady, wetter northern slopes. Simons reached the snow field and climbed to a height of 17,000 feet over a "tumbled up, heterogeneous mass of frozen snow and ice, with frightful precipices, bridges, caverns full of brilliant icicles, and all the other splendours and charms that make glacier travelling so enticing and so dangerous."[9] He determined the summit (not actually reached) as 17,500 feet. De Brettes who claimed to have determined the elevation by trigonometrical measurements in 1891 gave it as 5800 meters or 19,024 feet.

TRAVERSE FROM SANTA MARTA TO CERRO QUEMADO

Through the kindness of the American Consul, Mr. Flye, I also made a traverse up the Horqueta or northwest spur of the Nevadas. A good road suitable for automobiles links Santa Marta with Jamonica, some ten miles to the east (Fig. 9). The Manzanares River is crossed near the weir. Here is a prehistoric burying ground of the Indians, which to the writer seemed worthy of systematic excavation. Shards and skeletons were scattered around the graves, and I purchased some stone axes therefrom at the neighboring farm, which were as beautifully shaped and polished as any I have seen.

Mamatoco and Jamonica are villages inhabited by folk largely of Indian descent. But they have changed over to Colombian culture, and little resemble the community at San Andrés. Some of the most interesting features of this route are the ancient Indian roads. These are 3 or 4 feet wide and are built up of large flat stones. They originally extended throughout much of this region but are gradually being destroyed. So far the vegetation was of the xerophytic type,

[9] Simons, *op. cit.*, pp. 707–708.

FIG. 18—Panorama of the Sierra Nevada scarp, looking southeast from Cerro Quemado, 26 miles distant. The area above the snow line is shown (above the stipple area) and also the pyramid-and-cirque character of the summit (17,500 feet). The ranges in the foreground are covered with jungle and are from 5000 to 8000 feet high.

rich in cactus, but along the rivers the tropical mesophytic forest sent long tongues down into the lowland.

From Jamonica (1000 feet) I proceeded by muleback. The first coffee plantation was at 2400 feet, and the plants were heavily shaded by forest trees, unusually dense with a view to keeping down weeds, I was informed. Some maize was growing at 3500 feet, but in general the mule trail wound around hills clothed in thick jungle and dropping very steeply to tributaries of the Gaira or Manzanares rivers. Later on, extending far down the slopes of coffee plantations, I could see the iron pipes that deliver the coffee beans to the mill. Numerous zigzags following the divide led me into the next valley, the Toribia, and at length I reached the hacienda of Cincinnati at 4400 feet.

In the beautiful garden here one found oneself in a region of perpetual spring, the temperature varying little from 68° F. Clouds usually enveloped the house some part of every day, and rain was abundant. Bowers of purple or red Bougainvillea surrounded the house; violets and delicate ferns and roses abounded. Elderberry (*Sambucus*), orange, loganberry, and papaya flourished side by side. Hundreds of acres of coffee covered the steep slopes in every direction, while far down the valley the rushing stream drove the Pelton wheel of the coffee mill. Several thousand hectares of the steep slopes in this vicinity have been cleared of jungle and planted with coffee, although, because of the poor prices obtained for coffee in recent years, some planters are replacing part of their coffee with orange trees.

One morning I made the ascent of the Cerro Quemado (the Burnt Peak), which lies several miles to the east of the hacienda and 4000 feet higher. This mountain was once largely covered with jungle, but Mr. Flye decided to try grazing sheep thereon. He burnt off all the trees (hence the name) and built a two-story ranch house at the foot of the clearing. After some years the experiment was found to be too expensive, but the trail to the Cerro still remains and enables the traveler to obtain a unique panorama of the Santa Marta region. At first the trail climbs by means of sharp zigzags for 2000 feet through the densest jungle. Thereafter it follows the crest of a divide of a most picturesque character, with steep declivities on each side. This

TABLE I—THE CONTROL OF ENVIRONMENT (11° N.) BY ALTITUDE BASED ON A TRAVERSE TO THE EAST OF RIO FRIO

ALTITUDE IN FEET	ZONE	CHARACTERISTICS
19,000 15,000	Permanent Snow	The snow field covers the ridge-like summit and appears to be about ten miles wide from west to east. One or two small glaciers are visible on each face of the ridge. Cirques are abundant.
15,000 12,000	Glaciated Zone	Well formed lateral moraines occur on both northwest and southern slopes. Small tarns and cirque lakes occur. A Pleistocene glacier extended about twelve miles down the Cataca Valley.
12,000 10,000	Páramo	There are wide areas of rocky grasslands on the plateau, used by the Indians to a limited extent for cattle. Only patches of páramo occur on the steep northwest slopes.
9000	Upper Jungle (not utilized)	The upper portion carries grass, berries, the fern *Lomaria*, and dwarf bamboos. Lupines, various small rosette plants, small palms, and larger bamboos occur lower.
8000	"	Bamboo jungle, with some trees a foot in diameter. Undergrowth of sphagnum moss. Bracken in places. Small tree ferns abundant and many small ferns. *Lisianthus*, a large pink-flowering shrub. Herbs like yellow *Senecio*, *Bidens*.
7000	"	Small *Tillandsia* as epiphytes and also growing on stems two feet long in ground. *Lisianthus*, *Senecio*, pink *Phytolacca*, and purple *Eupatorium* here also.
6000	"	Palm and tree-fern jungle. Most trees are one to two feet in diameter and 40 feet high. Some are buttressed and 90 feet high. Large epiphytic *Tillandsia* common, and orchids like *Pleurothallis*.
5000	"	Large tree ferns 25 feet high, also thorny climbing ferns. Trees mostly about 50 feet high. Large *Tillandsias*, corymbs of *Verbesina*, and a purple pea (*Psoralea*) are common.
4000	Lower Jungle Coffee Zone	Much as above. A few trees 100 feet high. Some bracken. Two common shrubs at intermediate levels are *Baccharis* and *Cephaëlis*. Among smaller plants are *Calea caracasana* and *Asclepias curassavica*.
3000		Upper limit of coffee. Some sugar cane and beans also at this level. Cotton tree common. Few bananas.
2000	Lower Jungle Sugar-cane Zone	Many cotton trees (*Croton gossypiifolius*). "Caracole" and "macondo" trees. Much bracken and *platanillo*. Small ferns.
		Local grassland (due to fires), coarse, blady grass and the tough herb *Sida acuta*. Cycad-like ferns in gullies. Some papaya and sugar cane near houses.
1000	Xerophytic Zone	"Ma-agua," or bottle trees, and "stink-bark" trees in upper part. Thorny scrub with coarse grass in lower part. Some cactus.
20–100	Banana Zone	Where irrigable the above xerophytic vegetation is replaced by bananas. Large areas of cactus common.

is known locally as the Tapir's Path, for it was originally opened out by those large pachyderms. It may be noticed *en passant* that I saw no wild mammals, only one small snake, and no large bird throughout the whole of my journeys in the Colombian jungle. The local folk agree that the fauna is very limited on these western slopes but is much more abundant on the wetter northern aspect.

At about 7000 feet I reached the foot of the last slope, where several small creeks fell in cascades over the rocks. Here was a plentiful display of mosses, lichens, liverworts, and epiphytic ferns. Large tree ferns were abundant, as well as small palms or cycads. The trees were here only about 30 feet high and carried two types of epiphytic *Tillandsia*—one with long red flower spikes, the other with nearly sessile white flowers on a knob.

Around the sheep ranch at this elevation of 7200 feet the introduced loganberry flourished and had largely overgrown the original clearing. Many palms about 40 feet high rose above the jungle near by. The higher portion of the Cerro Quemado was largely clear of tree growth, and the top is covered with coarse grass interspersed with herbs like *Bidens* and *Vernonia*. I climbed up to 8000 feet late in the afternoon but was unable to see anything but a sea of clouds. Next day at 5 a. m. I again made my way up the Cerro.

Immediately below me to the southeast the mountain dropped several thousand feet into a series of valleys running approximately east and west (Fig. 18). There seemed to be three main valleys, whose divides were all well below 8000 feet. Farther to the southeast at a distance of 26 miles rose the great wall of the crest of the Nevadas. I could make out a long line of snow-capped peaks before the sun rose at 6 a. m. just behind the eastern snow field. Hence it was impossible to photograph or even to see clearly the most interesting feature in the landscape. However, I remained sketching what I could see until the rising clouds began to cover all the view on the southern side of the Cerro Quemado. On the lower, warmer slopes to the northwest the coast line could be clearly distinguished, from near Rio Frio to the coves and headlands north of Santa Marta.

The snow-capped crest of the Nevadas extended through a horizontal angle of 13 degrees. Allowing for the direction of the crest, we may perhaps estimate that the snow cap was ten miles long on the north face of the Nevada. Three pyramidal peaks formed the summit (17,500 feet), but a great deal of the crest—all that was snow-covered—is probably well over 15,000 feet. The north face is apparently very steep and drops quickly for several thousand feet for many miles on each side of the highest point. It seemed clear to me that an attack on the glaciers and the summit should be made from the southern páramo, somewhere in the vicinity of San Sebastian—just as Simons had done in 1881.

SETTLEMENT IN NORTHERN RHODESIA*

H. Clifford Darby

ECONOMICALLY Northern Rhodesia falls into two main divisions, North-Eastern and North-Western. In North-Western Rhodesia white settlement consists of an irregular belt of farms, chiefly maize and cattle, extending up to thirty miles on either side of the railway line which provides access to the sea at two Portuguese ports Beira and Lobito Bay, on the east and west coasts of Africa respectively, and southwards gives connection with the Union of South Africa. Beyond this belt of farms there live missionaries and traders, together with a few isolated ranchers; a few lumbermen are to be found along the river courses. The white population of North-Eastern Rhodesia is considerably less in number and is disposed in two groups. In the south, a colony of tobacco planters centers around Fort Jameson; the nearest railhead is at Blantyre in Nyasaland, some three hundred miles away. To the north, in the neighborhood of Abercorn, there is a smaller group of settlers engaged in coffee planting; these have an outlet to the sea via Lake Tanganyika and Dar-es-Salaam.

Hitherto, one of the fundamental facts in the development of the country has been its inaccessibility. Most parts of Northern Rhodesia are about a thousand miles from the seacoast. Within the last few years, however, a factor has arisen that is likely to revolutionize both the extent and the nature of permanent white settlement in the region. Today Northern Rhodesia stands in quite a different position from the other East African dependencies because of the prospects of enormous development held out by her mineral resources. The copper deposits in the north of the territory are a continuation of those of the Katanga region and were discovered at the beginning of the century. But the significance of the find was not realized until 1927–1928, when energetic prospecting revealed an extent of ore in the Ndola district hitherto unsuspected; ore, too, that is remarkable for its high copper content and for the ease with which the metal can be extracted.

The effects of this discovery may be gauged by the fact that, while in the 1921 census the entire white population of the country was only 3634, at the end of 1930 it was computed to be 15,000, having doubled itself within the three preceding years.

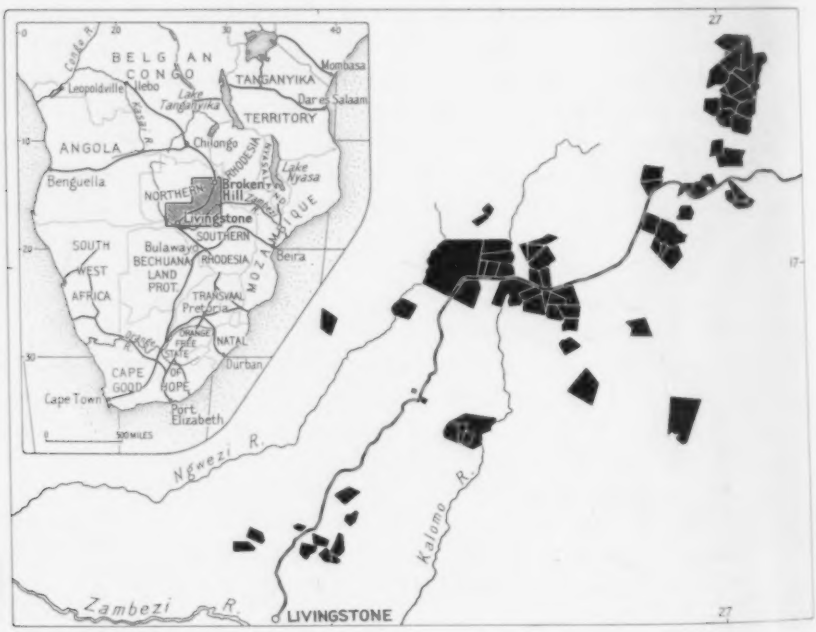
*Notes based on a visit to Southern Africa in 1929, following attendance at the South Africa Meeting of the British Association for the Advancement of Science.

To place these figures in perspective it is necessary to remember that the area of the country is not far short of 300,000 square miles and that its native population is well over one million.

Thus the first stage of settlement, which began a quarter of a century ago with the completion of the railway to Broken Hill, may be said to be at an end. Preliminary experimentation has outlined the main problems to be solved.

Pioneer Problems: The Cattle Industry

On a settlement prospectus of 1906, the Batoka Plateau between the Kafue and Zambezi rivers was marked as "good agricultural farming land." Today the area is of little farming importance. Its granitic soils are suited only for stock raising, and even this is attended by many difficulties. Stock deterioration invariably sets in, and it would appear that Northern Rhodesia cannot for some time expect to rear and mature highly bred stock under ranching conditions. The causes of the deterioration, however, cannot be stated until more data are available. They may in the first place be climatic—partly the consequence of a marked seasonal rainfall. Experiments in the preservation of pasture and in the grading of stock to suit local conditions have to be carried out, and these are all the more difficult in a land where grass fires are the rule. Secondly there is the question of some deficiency, probably mineral, in the pastures. This is receiving



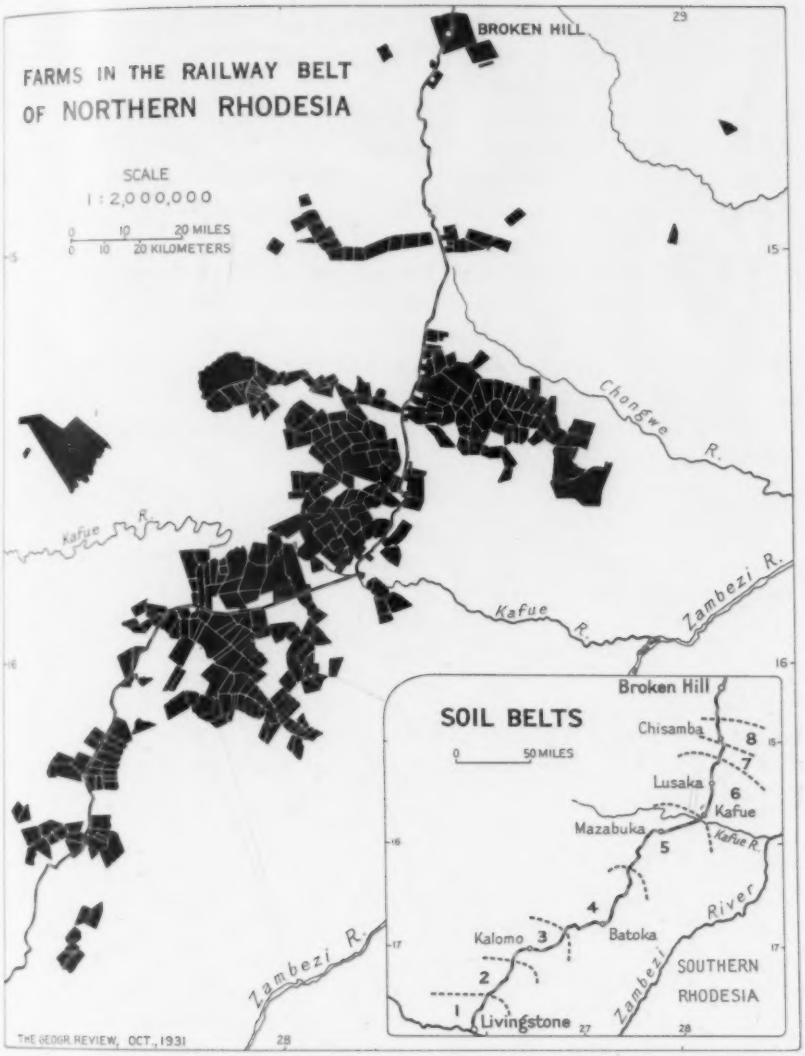


FIG. 1—Map showing stretch of railway line in Northern Rhodesia from the southern border to Broken Hill. The farms occupied up to August, 1929, are marked from information received at the Government Land Office at Livingstone. The farms are aligned in a belt stretching to 30 miles on either side the railway track. Many interruptions occur due in part to soil variations, e. g. the line of farms running east and west from Lusaka corresponds to a fertile limestone outcrop (see inset of soil belts). North of Broken Hill there are but few farms largely owing to soil conditions; those that exist are chiefly engaged in producing fruit for the mining populations.

The inset in the left-hand portion of the map shows the principal means of approach to Northern Rhodesia by rail from the seaboard. The scale is 1 : 75,000,000.

The inset in the right-hand portion of the map shows the main soil divisions along the railway belt in Northern Rhodesia. The underlying rock plays a dominant part in determining the soil type. Reference: 1, basalt overlain by Kalahari sand; 2, sandstone overlying coal measures; 3, granite intrusions into sandstone; 4, granite, serpentine, with occasional laterite; 5, lateritic soils, sand and clay loams, granite and basalt; 6, lateritic soils, clay loam, dolomitic soils, with occasionally alluvial deposits, limestone outcrop east to west of Lusaka; 7, wooded alluvial soil and clay loams, limestone. Numbers 1, 2, and 3 constitute primarily the cattle belt; 5, 6, and 7, the maize belt; 4 is a maize and cattle belt. The scale is 1 : 8,000,000.

increasing attention generally,[1] and the practice of feeding mineral rations to stock is spreading. Phosphorus is the element usually lacking, and in South Africa rations of phosphate compounds have given excellent results; in many cases the yield of wool and the live weight increase have actually been doubled. "There is little doubt," states Dr. Orr in his report "that within the next few years mineral fertilisers will be used in increasing quantities." The whole problem

TABLE I—RAINFALL AT STATIONS IN NORTHERN RHODESIA

CENTERS	AVERAGE IN INS.	1923–24	1924–25	1925–26	1926–27	1927–28	1928–29
Kaloma . . .	29	15	44	43	26	27	26
Mazabuka . .	32	18	52	39	29	24	38
Lusaka . . .	33	18	44	45	28	27	29
Chisamba . .	33	23	43	53	18	27	35
Average maize yields for Northern Rhodesia (bags per acre) . . .		3.08	2.67	4.87	5.50	4.90	5.50

is complicated by the fact that generations of insufficient grazing have encouraged the growth of coarse grasses of little feeding value, and suitable and improved varieties of pasture grasses have yet to be discovered.

Finally the ravages of cattle disease have to be overcome, and these have necessitated government interference and the placing of a quarantine qualification upon all imported stock.

A decade or so ago the settler struggled alone with these difficulties and gave up when his farm ceased to pay; but in 1929 a government research station was established at Mazabuka, providing facilities for the investigation of some of the many problems that confront the local farmer.

SOIL AND CLIMATE

While extensive geological investigations are in progress in the mineral concessions, few data are yet available.[2] Much valuable information regarding geology and vegetation in relation to soils is expected from the aerial survey recently completed.[3] The adjoining

[1] J. B. Orr: The Composition of Pastures, *Empire Marketing Board Publ. No. 18*, H. M. Stationery Office, London, 1929.

[2] J. Austen Bancroft and R. A. Pelletier: Notes on the General Geology of Northern Rhodesia, *Rept. Fifteenth Internatl. Geol. Congr., South Africa, 1929, Guide Book Excursion C-22.* See also Robert Murray-Hughes: The Geology of Part of North-Western Rhodesia, *Quart. Journ. Geol. Soc. of London*, Vol. 85, 1929, pp. 109–166.

[3] See C. K. Cochran-Patrick: Recent Reconnaissance Mapping in Northern Rhodesia, *Geogr. Rev.*, Vol. 21, 1931, pp. 213–220.

sketch (Fig. 1) gives some indication of the main surface formations of the settled belt on either side of the railway line together with the differences in agriculture that result therefrom.

The problem of each in[illegible] is increased by the fact that the soil variations within e[illegible] major divisions are very great, a state of affairs characteristic of [illegible]hole of Northern Rhodesia and indeed of a broader terrain. "S[illegible]al soil series are found in

TABLE II—INTENSITY OF RAINFALL IN SOUTH CENTRAL AFRICA AND ENGLAND COMPARED

(*Percentage of Annual Rainfall*)

AMOUNT PER DAY	MAZABUKA N. RHODESIA	ZOMBA* NYASALAND	GREENWICH ENGLAND
0.01–0.10	3.1	5.4	16.2
0.10–0.25	9.2	7.0	28.0
0.25–0.50	17.2	20.9	30.8
0.50–1.00	26.4	40.1	20.0
Over 1.00	44.2	26.6	5.0

*A. J. W. Hornby, *op. cit.*

the semihumid and semiarid areas of South Central Africa which vary greatly in composition, and the demarcation line is often sharp between them," says the Agricultural Chemist of Nyasaland.[4] In addition to the wider influences of climate and topography in soil evolution a variety of local causes produce local soil variation. The limits of disappeared vleis leave their mark in differences of soil content; the action of soil erosion in detail, the presence of ant heaps, native occupation, the one-time haunts of big game all produce soil differences. By local experiment alone has the farmer been able to decide what portions of his land he is to plow, and such experience may be disastrous; for a loss in yield of a few bags an acre over a large number of fields may reduce a year's efforts to an uneconomic basis.

Then there is the great variation in weather from year to year In Northern Rhodesia no year may be said to be normal from a climatic point of view. Variability is illustrated in Table I. After a dry year in 1923 many farmers went in for cotton; but the following year, 1924, when 16,700 acres were planted in cotton, proved very wet and the crop was a complete failure. So too was the succeeding year, and cultivation has been temporarily abandoned until new varieties of cotton suited to Northern Rhodesian conditions can be evolved. Such failures mean each time that the limits of the settled

[4] A. J. W. Hornby: Studies on Three Important Soil Series of Nyasaland, *Dept. of Agric., Agronomic Ser. Bull. No. 3*, Zomba, 1930.

FIG. 2—Oblique aerial view of Broken Hill. Government offices in the center foreground; a part of the airdrome in the right foreground; in the middle center the mine, with mine plant and the railway station and residential quarters in the background. (Photograph by Aircraft Operating Company.)

area have been reduced, for farmers have to abandon their farms temporarily at least. In addition to seasonal rainfall variations are other variations in place. The difference in annual precipitation between adjacent farms may be as much as 12 inches in any one year, and the following year the respective amounts may easily be reversed. The importance of the consequent fluctuations in yield to a settler with a small capital margin cannot be overestimated.

SOIL EROSION

Rainfall is unfavorable in another sense too. A succession of heavy thunderstorms following long months of drought results not only in the washing away of soil but in the leaching out of salts; and many settlers, not aware of the methods of combating this menace and not appreciating its seriousness, are soon faced with diminishing crop returns. This feature of the rainfall of south central Africa in

FIG. 3—Oblique aerial view of the Roan Antelope mine plant at Luanshya. The Roan Antelope is the first of the mines of the new Northern Rhodesian copper fields to start production. (Photograph by Aircraft Operating Company.)

comparison with a humid temperate climate rainfall is illustrated in Table II.

The native practice of annual grass burning further intensifies the problem of soil washing, as it reduces the humus content of the soil and makes it more liable to erosion. Such quantitative measurements of soil erosion as are available from south central Africa leave no doubt as to its serious nature. In the Mazoe district of Southern Rhodesia it is estimated that ¼ inch of soil is lost annually from the cultivated land.[5] On one farm the original yield of maize of 20 bags to the acre dropped to 4 bags. Green cropping and use of artificial fertilizers prove of little avail, for both soil and fertilizer are washed away.

It is proposed to maintain certain areas as protection forests for prevention of soil erosion and for the preservation of water supplies in springs and rivers.

[5] *Rhodesia Agric. Journ.*, Vol. 25, 1928, p. 1220.

FIG. 4—Clearing the bush, Araluen farm, Kalomo, 1906–1907.

DIFFICULTIES OF COÖPERATION

The tendency among a majority of the settlers at first was, and indeed still is to a large extent, to concentrate upon a single crop. The cotton and the tobacco crises and the bad maize seasons took their toll, for at such times the farmers who had planted these alone had no subsidiary crops to fall back upon. And even if a settler indulged in a little mixed farming to supplement his income, how was he to dispose of his produce? In 1928 many producers experienced difficulty in disposing of the small amount of beans they had grown, and yet at the same time one mining contractor in the north was compelled to import beans because his requirements were greater than the total amount produced in Northern Rhodesia. One great defect was the lack of organization. Local associations and coöperative schemes had to be initiated, and experience has yet

FIG. 5—Farm buildings, Araluen.

[1] *Rhodesia Agric. Journ.*, Vol. 25, 1928, p. 1220.

FIG. 6—Plowing by crude oil tractor, Chisamba.

to provide complete coördination between the various branches of production. The difficulty is felt in another way. A farmer may be ruined by a crop failure; yet, if he could keep going for some time and recuperate in a few good seasons, success might yet be his. But the territory, unlike Southern Rhodesia, has no Land Bank to provide long-period loans at a low rate of interest, and the farmer has to manage in the best way he can. In the older communities it is possible to make a livelihood without making a great success, but the settler in these lands has to make a great success of his farming even to make a livelihood at all.

There are other difficulties, personal factors formidable in themselves. Long hours, constant toil, grueling heat, the pestilent mosquitoes, malaria; months during the rainy season when communication with the outside world is difficult if not impossible; no social intercourse beyond that of the native; the long railway journey and con-

FIG. 7—Settler's farm, about 30 miles from the railway, Mazabuka.

FIG. 8—Ox team and wagon.

sequent high fares to the coast, which prohibits vacations—these are a few of the trials of a settler's life. The annual agricultural show at Kafue has become the great social event of the territory, an occasion on which all settlers have opportunities of meeting one another. Not that they do not make opportunities on other occasions; for the activities of local cricket and football teams, whose members are drawn from wide areas, represent a triumph over great obstacles.

In view of the difficulties it is not to be wondered at that an attitude of caution has been adopted by the Government towards future settlement. The Governor of the territory declared (East Africa Settlement Supplement, 1927) in 1927:

> I should not wish to invite settlers into the country without a reasonable certainty that they would be able to make good, and I think that for the present a cautious policy will be wisest.

FIG. 9—Typical motor road, Lusaka.

FIG. 7—Settler's farm, about 30 miles from the railway, Mazabuka.

FIG. 10—Agricultural research station, Mazabuka.

He adds that further experimental work on payable export crops is also desirable. Promise of such work in the form of a survey was held out in the Department of Agriculture's Report for 1927:

> An ecological survey would deal primarily with the classification of the chief types of vegetation in relation to climate, rainfall and soil types of their habitats. Such a survey, where the country is mapped out into areas, in each of which the relationship of vegetation to environment is recorded, would be of the greatest use as a preliminary guide to the possibilities of agricultural development in particular localities. The knowledge obtained would be of great assistance in delineating areas suitable for settlement.

An Agricultural Survey Commission has been appointed for the purpose of reporting upon the unalienated land suitable for farming within twenty-five miles of the railway. This commission will advise intending settlers as to what class of farming or ranching is adapted to different areas. The Agricultural Report for 1930 states that operations were commenced at the beginning of the dry season.

FIG. 11—Irrigation channel at Makeri farm, Lusaka.

FIG. 9—Typical motor road, Lusaka.

FIG. 12—Oblique aerial view of the Victoria Falls and of the railway bridge connecting Northern and Southern Rhodesia. (Photograph by Aircraft Operating Company.)

MECHANIZATION OF AGRICULTURE AND TRANSPORT

Despite these difficulties, however, a fair amount of land has been taken up. The older group of pioneers—those of the first decade of the century, who in the main trekked in from the south—were reinforced by post-war emigration from England and from the Union of South Africa. Now all the farms along the railway line are being taken up, and a great wave of enthusiasm has swept over the area. The possibilities of new railway construction enhance the prospect. A line from Nchanga and Kansanshi to link up with the Benguella Railway, now open (1931), and the proposed cut-off from Sinoia in Southern Rhodesia to Kafue would open up vast tracts of land to settlement.

The agriculture of the future will be different in character too. It is being industrialized. Northern Rhodesia, swept into the orbit of mechanical efficiency, is following the history of the more southerly portions of Africa. The debt of southern Africa to ox energy is very great: indeed it made possible the opening up of the subcontinent. What it actually amounts to on the farm is a little difficult to assess. Oxen can be sold after many years of service, and their maintenance

FIG. 11—Irrigation channel at Makeri farm, Lusaka.

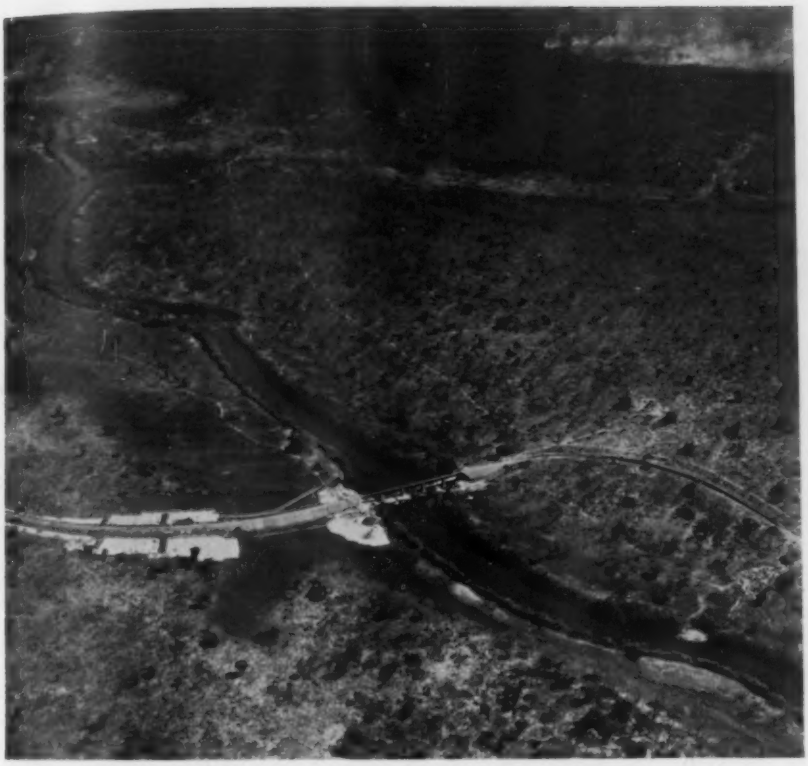


FIG. 13—Oblique aerial view of the crossing of the Kafue River by the railway extension line to N'kana, opened in the summer of 1930. Smoke from a bush fire in the background. (Photograph by Aircraft Operating Company.)

is comparatively cheap. But the efficiency of the tractor is unchallenged, and its increased speed is important in that advantage may be taken of favorable spells of rainfall during the sowing period. However, there remains the question whether such efficiency compensates for the high cost of operating. The inland situation of the area necessitates the transport of petrol and fuel paraffin over long railroad distance. Petrol, at one and eight pence a gallon in Cape Town, costs more than four shillings in Northern Rhodesia. It is possible that a solution may be found both in the use of new fuels and in technical improvements in tractor manufacture. Mechanical means must be employed within the tsetse fly areas and are more common in Southern Rhodesia than in Northern Rhodesia.

So, too, for transport. That teams of 16 oxen can be trained to work in unison across most difficult country, through river beds, over boulders, and along steep and winding drifts is a remarkable achievement; but the loads and the distance they can be carried are restricted. The variability of many factors makes it difficult to estimate the limiting distance from the railway that ox transport places upon

farming, but 30 miles may be accepted as an absolute maximum for maize. Lack of capital reduces the figure. If the farmer cannot buy more than one team of oxen he is economically confined to within 10 miles of the line, because only then can he bring a load a day to the railway and clear his crop. Higher priced crops can be grown much farther away. The tobacco of the Fort Jameson district of

FIG. 14—Lusaka, which now replaces Livingstone as the capital of Northern Rhodesia. Lusaka is almost midway between Livingstone and the copper fields of the north and occupies a healthful site at an altitude of over 4000 feet.

North-Eastern Rhodesia is brought by motor lorry to railhead at Lumbe in Nyasaland—a distance of 300 miles.

The railway in Northern Rhodesia was built to serve the mines rather than open up the country agriculturally. It has the peculiarity that the track is as far as possible a "contour line," keeping to the main watershed areas. This zone naturally has been the zone of greatest soil erosion and often is not as rich as pockets of good soil some distance away. In the location of farm sites the advantage of being on the railway may thus be counterbalanced economically by the greater fertility of a more remote site. Thus the problem of feeder roads assumes peculiar importance. There is need of devising some means of transportation which by big load capacity will be cheap in cost per ton mile and yet will not demand the building of a heavy track. The need may be expressed this way. A train has a ton-mile capacity per day of 150,000 and more (load 500 tons, distance 300 miles), an ox wagon a capacity of less than 100 (5 tons, 12 miles). The problem is to find some mean between these extremes, and the small motor lorry with 500 ton-mile capacity scarcely bridges the gap. Experiments are in progress; and, as the latest Annual Colonial Report states, "The continual development of the six-wheeled lorry and the roadless tractor is being watched with interest; and it is anticipated that the next few years will see a complete revolution in the existing transport position."

Mechanization of agriculture is necessary for another reason. The demand of the mines for native labor and the efficient labor-recruiting organization of the mining companies is already affecting the individual farmer: he may soon have to face a labor shortage. Furthermore, he may have a problem in native competition. While native-grown maize does not figure largely on the market in Northern Rhodesia as yet—it is estimated that 35,000 bags were sold in 1929[6]—in the Mazoe district of Southern Rhodesia 60,000 bags from the Chiweshe Reserve alone were sold in 1928.

The new markets provided by the mines, however, have the advantage of not being limited to one or two commodities. All that can be produced can be absorbed, and the spread of mixed farming will relieve the farmer of his dependence upon seasonal oscillations of crops. This is the real economic problem of the early pioneer, for in the past the failure of any crop meant complete ruin; but now such failure in any year will be compensated by the success of other crops, thus increasing the margin of safety of the individual settler. Above all, the essentially individual nature of the effort of the early days is disappearing. The mining companies require to be assured of their supplies from year to year. Organization and coöperative activities would seem to be the features of the future. The age of the pioneer is passing, and the period of primary settlement is drawing to an end. But this does not mean the disappearance of the problems of settlement: in fact they are only really beginning. Chief among them are those connected with need of devising some *modus vivendi* between the white man and the native. The problems of the future, however, are social rather than individual.

[6] Northern Rhodesia, Report for 1929, *Ann. Colonial Repts. No. 1516*, London, 1931.

THE DRAINAGE OF THE ZUIDER ZEE

K. Jansma

Secretary of the Zuider Zee Board

FIG. 1—Wieringermeer polder. Rye field, May, 1931: a year ago this was under the sea.

IF all the dikes the Dutch people have constructed during the course of the centuries were to be removed, a great part of Holland would disappear under water. The struggle has been continuous both against the North Sea and against the rivers, and in its course the waters have at times been victorious. Although but few exact data are available it is well known that a large part of the Zuider Zee was formerly dry land: instead of the present large body of water, there being only the rather small Flevo lake.[1] We know the names and something of the history of cities and villages that existed where today ships sail and fish swim.

EARLIER RECLAMATION SCHEMES

The seventeenth century proved the turning point in the struggle with the sea. In this century, the period of Holland's greatest national prosperity, she not only strove after expansion overseas, but she also consolidated her internal position with regard to the water.

There was even a counteroffense. One by one a number of large lakes were drained, especially in the province of North Holland, and in this way excellent land was reclaimed. At the end of the seventeenth century there was only one large lake left, the so-called Haarlem Lake, measuring about 44,000 acres. It was not until the nineteenth century, after the invention of the steam engine, that this last lake could be taken in hand: it was drained between 1849 and 1852.

The project of draining the Zuider Zee with its far larger surface

[1] Compare P. Tesch: Physiographic Regions of the Netherlands, *Geogr. Rev.*, Vol. 13, 1923, pp. 507–517.

could not be seriously entertained in the seventeenth century. However, the first hint of this daring scheme appears in 1667, in a book by Hendric Stevin who also recommended the construction of a canal from Amsterdam through the dunes to the North Sea, a project that was carried out with great success some two hundred years later.

The Zuider Zee Society

When in 1849 the drainage of Haarlem Lake was begun new schemes for draining the Zuider Zee were put forward. Between 1849 and 1886 a certain number of them, more or less carefully drafted, were made public. In the latter year an important step forward was made with the conclusion that a satisfactory solution would be impossible without proper scientific research. For this reason the Zuider Zee Society was founded, a private corporation which appointed a young engineer of promise, Mr. C. Lely, to take charge of the investigation. For five years Lely devoted all his time and energy to this important task. In 1891 he presented his plan, the classical solution of the problem, which is now being carried out. By a happy coincidence Lely was not only an able engineer but also a statesman. Shortly after the presentation of his Zuider Zee scheme he became Minister for Public Works, an office which he held twice again with great distinction. It gave him a unique opportunity of pushing his great scheme forward, though it was only during his third term of office, in 1918, that he had the satisfaction of seeing the scheme unanimously adopted by the Dutch parliament. From the beginning of the work, in 1919, till his death in January, 1929, Dr. Lely was

FIG. 2—Map illustrating the Zuider Zee reclamation project. The enclosing dam runs from North Holland to Friesland via Wieringen Island. Of the four polders planned the northwestern (Wieringermeer polder) has already become dry. Scale 1 : 3,500,000.

FIG. 3—The beginning of a dike, October, 1927. (Photograph by Koninklijke Luchtvaart Maatshappij.)

President of the Zuider Zee Board. It goes without saying that his name is inseparably connected with the drainage of the Zuider Zee and the creation of Holland's new province.

OBJECTIONS TO THE SCHEME

The long period of twenty-seven years between the promulgation of the scheme and its adoption was necessary to overcome the objections advanced against it, especially in agricultural circles. It was feared that the addition of so much land would result in a heavy drop in prices and rents. But now all are agreed that Holland is a greatly overpopulated country, with a shortage of good land, which

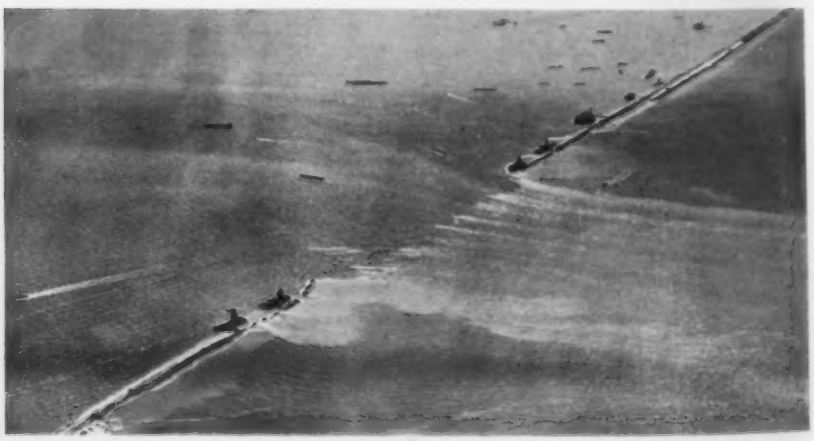


FIG. 4—The last gap in the dike between Wieringen and Medemblik, July, 1929. (Photograph by K. L. M.)

FIG. 5—The central part of the main dike: the two harbors of Breezand. (Photograph by K. L. M.)

even the new Zuider Zee province will not be able to satisfy. Holland has a population of no less than 600 to the square mile.

Another and far more important objection was based on the heavy expense involved, heavy at least for a country of the size of Holland. Before the war the estimated cost was 80 million dollars—a sum equivalent to the entire national budget at that time. The war, however, did Holland one great service, that people became accustomed to large figures. To a nation that had had to spend hundreds of millions of dollars for the mobilization of the army and the distribution of foodstuffs the sum of 80 millions looked considerably smaller in 1918 than in 1913. Also the cutting off of supplies during the war had demonstrated the value of an undertaking which at least to some extent contributed to make the country self-supporting.

FIG. 6—A floating crane discharging boulder clay on a dike under construction near Medemblik. (Photograph by International Persfoto Bureau.)

Other Advantages of the Scheme

The main feature of Dr. Lely's scheme is the enormous dike that will shut off the Zuider Zee from the North Sea, so that the former will be reduced to an inland lake. The dike has been projected not at the narrowest part of the Zuider Zee but at a place where it is particularly shallow—generally not more than twelve feet in depth

Fig. 7—Lock and sluices under construction at Kornwerderzand. (Photograph by K. L. M.)

and often less. It runs between Wieringen and North Holland, a distance of a mile and a half, and from Wieringen to Friesland, about 19 miles. If all goes well the dike will be closed in the summer of 1932.

The great dike planned to facilitate the draining of the land behind it presents other advantages for the surrounding country. Indeed it has been calculated that apart from reclamation the dike would render such service as would alone justify construction.

In the first place the country behind the dike will have no more to fear from the North Sea storms that ever since the Middle Ages have been a winter menace. The present Zuider Zee dikes will become a second line of defense and will no longer require the present expenditure on upkeep. Floods like that of 1915, when a large part of the country near Amsterdam was inundated and considerable damage done, will occur no more.

Even more important is the fact that the water behind the dike will freshen, because of the constant discharge from the Yssel and other rivers. Thus a large reservoir of fresh water will be created in the middle of the country, from which it will be possible to draw as much

(Photograph by International Persfoto Bureau.)

as is wanted even during the driest summers. At present the peasants in North Holland and Friesland often have to let in salt water from the sea, which is bad both for the fields and the cattle. This new water supply may mean the saving of millions of dollars during a single dry summer.

Whilst in dry summers the surrounding country has a shortage of water, at other times of the year there is often an embarrassing

FIG. 8—Experimental polder near Andyk under construction, October, 1927. (Photograph by K. L. M.)

plethora. The situation will be improved with the sea behind the dike maintained on a constant low level. Furthermore, the dam will be used for railway and road communication between North Holland and Friesland.

CONSTRUCTION OF THE GREAT DIKE

The dam is of such magnitude that it has no parallel in Holland nor, it is believed, in the rest of the world. At the base it will be about 300 feet wide; the height above the water will be about 25 feet. Even during the heaviest storms no wave will be able to surmount it. It will consist mainly of sand, but on the northern side there will be a heavy mass of clay, a thick layer of which will likewise cover the whole dike.

When the work was begun in 1920 one of the great practical difficulties was to find a source from which to obtain the large quantity of clay that was necessary: indeed, it formed one of the chief technical

objections against the scheme. By a most fortunate coincidence the Zuider Zee itself furnished the clay; on its floor were discovered sufficient deposits of tough boulder clay, an almost ideal material, as it is proof against very strong currents. In the closing of a dike the tidal current may obtain a velocity of as much as 21 feet a second; but even in these circumstances the boulder clay is resistant. The clay is dredged up and transported by water to the desired spot

FIG. 9—Wieringermeer becoming dry, May, 1930. (Photograph by K. L. M.)

and there dropped. The sand that is required is dredged into lighters, mixed with water, and pumped through long iron pipes to the destination. By another method sand is carried on a long moving band that drops it at the right place.

The surface of the dike is faced with stone imported from Belgium and Germany. As Dutch workmen have had but little experience in this kind of stone work, a small number of Italians have been employed; otherwise the whole work is carried out by Dutch labor. Indeed one of the arguments in favor of the scheme is that it gives employment to several thousand workmen, a cogent argument in these times of depression.

For the purposes of shipping, locks have been projected sufficient to accommodate vessels up to 2000 tons. The locks are being built in two groups, one on either side of the dike between Wieringen and Friesland. Intercommunication between the waters is also maintained by a system of 25 sluices, 15 near Wieringen, the others about three miles from the Frisian coast. The function of these sluices, which will each be 40 feet wide, will be the discharge of the water from the Yssel Lake, which flows into the sea behind the dike mainly from

of clay that was necessary: indeed, it formed one of the chief technical

one of the branches of the Rhine, the Yssel. The sluices will be closed at high tide and opened at low tide. At the time of writing the locks and sluices are nearly completed. Their total cost will amount to 40 or 45 million dollars.

Originally it had been proposed to construct the locks and sluices on the island of Wieringen, a plan that would have necessitated the expropriation of considerable land at a heavy expense. To the dis-

FIG. 10—Newly parceled land in the Wieringermeer polder. (Photograph by K. L. M.)

appointment of speculators who hoped to profit thereby the engineers discovered that it was possible to carry out the construction in the water. A substantial dike is built round the site selected and the water pumped out; locks and sluices are then built on the dry surface thus obtained, and the dike is removed.

A special committee presided over by Professor Lorentz has calculated the influence the building of the main dike will have on the rise of the tides. We now know how high the dikes to the north of the main dike will have to be made.

MAKING THE POLDERS

The next phase of the scheme is the creation of the polders behind the dike. It is not possible to drain the whole of the Zuider Zee. Dr. Lely calculated—and all experts agree with him—that it is necessary to leave a lake of some 280,000 acres with a view to the discharge of the Yssel. This water must flow naturally through the sluices in the dike at low tide; but when there is a northwest wind the discharge will be stopped and the water will be kept inside the Zuider Zee. There

is need, therefore, of a large reservoir in which to keep the water in case discharge should prove impossible during several days.

Given the surface of the lake, its form and that of the polders were largely determined by the geological nature of the subsoil. What is drained is largely clay or other good soil; the lake will occupy a sandy area. The four polders will have a total area of about 550,000 acres of the best soil to be found. They will increase the arable area of Holland by about ten per cent and probably will be able to accommodate between 300,000 and 500,000 people. The expenditure will be about 400 million dollars.

In 1925 the need of new land was considered to be so urgent that it was decided to start the northwest polder simultaneously with the dike. The decision involved an extra expense, as the eastern dike of the northwest polder had to be heavier than it would be according to Dr. Lely's scheme, in which it was merely a second line of defense. However, it was considered to be worth while in order to have this polder ready seven or eight years earlier.

The northwestern, or Wieringermeer, polder became dry in the summer of 1930 and is at present being prepared for cultivation. As a first step a system of canals was constructed inside the polder; in fact they were actually made while the polder was still under water! Calculations had shown that it was cheaper to dig them by dredging than to construct them "in the dry" after the water had been pumped out. Incidentally this method facilitated the flow of the waters to the pumping stations.

The polder is subdivided into four sections in accordance with the levels of the surface. In these sections the water level will provisionally be maintained at 15 feet 2 inches, 17 feet 5 inches, 19 feet 8 inches, and 22 feet, respectively, below normal Amsterdam level; the result being that in each of the sections the water level will be at 4 feet 8 inches below the surface of the lowest land in the section, a situation which is considered as being most favorable for agriculture.

Several years must elapse before the new soil reaches its full value. For centuries it has been covered by sea water and is heavily impregnated with salt. To discover the best system for rendering the soil fit for cultivation a small so-called experimental polder measuring 100 acres was drained near Andyk in 1927.

Land Tenure in the Polders

The parceling of the new land has received ample consideration. As recommended by a Royal Commission, most parcels will have a surface of 40 acres with a length of 880 yards and a width of 275 yards. They will be accessible both by road and by small boats. In some parts of the polder a different system is being tried out; here the

parcels will be considerably larger and will be accessible by ships of 80 to 100 metric tons. Villages have been projected along the main roads at distances of about two and a half miles.

Besides the numerous technical problems connected with the reclamation of the Zuider Zee there is also an important legal and social problem. What will be the ultimate relation in law between the new province and its inhabitants? On former occasions it was usual to sell the new soil by public auction at the earliest opportunity, and this very simple system is still advocated in some quarters. Diametrically opposed to it is the socialist proposal of keeping the land in the hands of the state and cultivating it as a state enterprise. Several intermediate courses can be chosen; the soil might be leased either for long or for short terms. No decision has yet been arrived at; only one thing is clear, viz. that as long as the present depression lasts it is out of the question to sell the land. A considerable loss on the whole enterprise would inevitably be the result. It is a fortunate circumstance that the state can bide its time.

A New Province

The total costs of the drainage works have been estimated at about 150 million dollars; or with compound interest 220 million dollars. This estimate has been exceeded, as is not unusual with public works; the northwest polder has even cost 62 per cent more than had been estimated. Should the cost of the remaining polders increase in the same ratio the whole enterprise will show a deficit of about 80 million dollars. It is hoped, however, that the experience acquired during the construction of the first polder will make it possible to carry out the rest of the work in a far more economical way. Even if this hope should prove delusive, it is felt that the acquisition of a whole new province presents such enormous advantages to the country as a whole that the completed project will be worth its cost.

A Frenchman once said, "God created the world, except Holland; Holland was created by the Dutch." It falls to the lot of the present generation to be able to create a new province, a virgin territory to be disposed of for the common benefit.

DID COLUMBUS DISCOVER THE ISLANDS ANTIGUA AND ST. MARTIN?*

Lucius L. Hubbard

ON September 25, 1493, Columbus left Spain on his second expedition to the West Indies. With him, on board the *Niña*, as master cartographer (*maestro de hacer cartas*) went Juan de la Cosa, a member of the first expedition and afterwards author of the first map (1500) to show the discoveries of those voyages.[1] Another member of the company, sent by royal appointment, was Dr. Diego Alvarez Chanca, physician to the fleet, who wrote an account of the voyage out but not of the return. Of the latter we have only one account, by Ferdinand Columbus,[2] of which I shall have occasion to speak in another place.

Several other contemporary narratives of the second voyage out have come down to us. Besides Fernando's, the one that seems after Chanca's to give the most correct account of Columbus' itinerary is by Peter Martyr, but in some respects it is faulty. Navarrete[3] reprints Chanca's account rather than Martyr's because he says that Martyr's is based on what he heard and Chanca's on what he saw. Martyr's account was printed at Seville (Hispali) in 1511, by Jacob Corumberger, under the title "P. Martyris Angli Mediolanensis opera,"[4] etc., with a map. This early work in Latin contains the first decade of the later work and covers the first three voyages of Columbus. In 1530 the full work, eight decades, also in Latin, appeared under the title "De Orbe Novo." In the following pages I quote from a French translation by Gaffarel, Paris, 1907.

It is foreign to my purpose to compare *in extenso* the narratives of Martyr and Fernando on the one side with that of Chanca on the other, but in passing I may remark that these three accounts of the voyage out are so much alike in general details as to raise the suspicion

* In the preparation of this paper the author has been greatly aided by material in the William L. Clements Library at the University of Michigan, and he hereby expresses his obligation to Dr. Randolph G. Adams and other officers of the library and to Professor L. C. Karpinski. He is also under obligations to Colonel Lawrence Martin of the Library of Congress for valuable assistance.

[1] Henry Harrisse: Christophe Colomb, Paris, 1884, Vol. 2, p. 53; also Antonio Vascáno: Ensayo biográfico del . . . Juan de la Cosa, Madrid, 1892, p. 16.

[2] Historie del S. D. Fernando Colombo, etc., Venetia, 1571; to which I shall refer as "Fernando" or "F. C."

[3] M. F. de Navarrete: Colección de los viages y descubrimientos, etc., Madrid, 1825, Vol. 1, p. 198. A new English translation by Cecil Jane is published parallel with Navarrete's text in *Hakluyt Soc. Publs.* Ser. 2, No. 65, Vol. 1, London, 1929.

[4] The first decade had been surreptitiously utilized in "Storia della letteratura italiana," Vol. 6, Part I, p. 167, Venice, 1507 (J. B. Muñoz: Geschichte der Neuen Welt, Weimar, 1795, p. 27) and in 1504 in a "Libretto" printed at Venice. See below, footnote 23.

that either the earliest of the three formed the basis of the other two or that Martyr and Fernando drew from a source none other than Columbus himself. No account by Columbus has come down to us, but Harrisse[5] thinks that Fernando, and Las Casas also, had in possession original texts of this voyage. In any event we may safely rely on the testimony of the two eyewitnesses, Chanca and La Cosa, to give us Columbus' itinerary through the Antilles and check it, if necessary, against the statements of Martyr and Fernando where inconsistencies seem to exist. Later I shall briefly notice other "authorities" on the voyage, who do not, however, add anything of importance to the facts covered by Chanca.

The La Cosa Map

The only original of the La Cosa map in existence, so far as I can ascertain, formerly in the collection of Baron Walckenaer and after his death purchased by the Spanish Government, now hangs in a frame in the Naval Museum at Madrid. Drawings from it, in whole or in part,[6] have several times been published, and in 1929 it was photographed under the direction of Professor L. C. Karpinski. The camera brought out islands and names that were probably not recognizable or decipherable in the original by the aid of the ordinary magnifying glasses, and Professor Karpinski thinks that the faintness of these inscriptions in the original may account for omissions noted in some of the reproductions. The orthography of one of these, printed in colors by Antonio Vascáno,[7] is in places obscure. I have utilized the Karpinski photographic copy, on which the area under consideration is shown on Figure 1. Figure 2, drawn from a modern chart, covers the same area and shows the principal islands recorded by Columbus or La Cosa as we now know them. On it are given both the altitude and what I call the zero visibility, i. e. the distance from which the islands can just not be seen.[8] At any less distance they should theoretically, under most favorable atmospheric conditions, come into view, but I am led to believe from statements in the "West Indies Pilot" that even this theoretical visibility is greatly in excess of the

[5] *Op. cit.*, Vol. 2, p. 65.

[6] Two reproductions described as from the original map and a "fragment" were, according to Dr. F. C. Wieder (personal letter), published by Humboldt first in his *Examen critique*, etc., Paris, 1839, and later in his *Atlas physique*, etc. These differ in some respects from the Karpinski photograph and from each other.

[7] For the title of Vascano's pamphlet see footnote 1. Consult also Catalogue of Maps, Plans and Charts in the Map Room of the Dominion Archives, Ottawa, 1912, pp. 557–562; and Henry Stevens' reproduction of E. F. Jomard's drawing, in "Historical and Geographical Notes on the Earliest Discoveries in America," New Haven and London, 1869. The Jomard map is an excellent reproduction, but not a facsimile, as will be seen in the intersections of several lines that cross the area under consideration, and the misspelling of several island names, such as *darajujca* for *domynyca*.

[8] For method of computation see my article "Did Columbus Discover Tobago," p. 216 in "Essays Offered to Herbert Putnam" (Yale University Press, 1929). In the figures on zero visibility given here I have considered the eye of the observer as at sea level.

actual; in the days before Lippershey and Galileo the mariner had to depend on the naked eye and the masthead to discern distant land. On Figure 2 a line drawn through Guadeloupe and the Nevis-St. Chris-

FIG. 1—Reproduction of a portion of the La Cosa map from a photograph made under the direction of Professor L. C. Karpinski.

topher group runs very nearly N. 45° W. A similar line found on the La Cosa map runs about N. 55° W., the difference being supposedly attributable to the change in magnetic variation that has taken place in the intervening four centuries. The La Cosa line at least shows accuracy in the relative positions of these islands. The shape and relative size of the latter cannot be expected to be equally accurate.

drawn as these were from one side only. The official character of La Cosa and the record he has left us are of weight, positively for the things he himself saw and perhaps negatively for some things that he has omitted.

My chief task is to show that Columbus, according to the best evidence, did not pass near and probably did not see the modern

FIG. 2—Map showing the probable trace of the second voyage of Columbus in the Antilles. The highest elevations of the islands, in feet, are from the British Admiralty chart, "West India Islands and Caribbean Sea," Sheet II, No. 762 ("compiled from the most recent surveys, 1914"). The arcs subtended from the elevations show zero visibility, i. e. the distance from which the islands can just not be seen. [For the elevation of St. John read 1230.]

Antigua and that the island St. Martin of Fernando Columbus and others may not be the *S. martin* of La Cosa. I have indicated on the map, Figure 2, the supposed track of Columbus, between Guadeloupe and the Virgin Islands, as inferred from Chanca and have given a résumé of the itinerary of the second voyage in Table I (p. 594). It is not material, so far as I can see, whether Columbus sailed up the west or up the east side of the islands after he left Guadeloupe. The shorter passage to Hispaniola would, of course, be up the west side. Dr. Chanca says they followed a direct route to reach that island, as direct by the goodness of God and the intelligence of the Admiral, as if they were following a known and frequented course (Navarrete, Vol. 1,

p. 202). But on the east side the fleet, if coursing near the islands, would probably find more uniform sailing conditions when exposed to the prevailing trade winds. The "West Indies Pilot" (Vol. 2, 1920, p. 224) says, for example, "Vessels sailing under the lee of Dominica island should be on their guard against the heavy squalls which come off the high land and through the deep valleys, blowing with great force during the strong trades. . . . When the trades are light, calms are frequent." Dr. Chanca, indeed, speaks of being becalmed on the first day's run when they were under the lee of Guadeloupe.

The Landfall

Having disposed of these preliminaries, let us now follow the Chanca text with the La Cosa map, from the arrival of the fleet opposite Dominica. On November 3, 1493, the first Sunday after All Saints, says Chanca, the cry of "land" was heard from the Admiral's ship about dawn. Ahead of the fleet—it was composed of 17 caravels scattered over the sea—appeared an island and soon, on the right, another.

Oviedo[9] says the first landfall was *la desseada* (Désirade). This name is faintly discernible on the La Cosa map opposite an island in nearly the correct place for Désirade, and the island may have been seen by one or more of the caravels, or La Cosa himself may have seen and mapped it during the week the fleet remained at Guadeloupe. There is no evidence that he came back that way with Columbus in 1496.

On the other hand, when we remember that La Cosa's map shows other islands, farther south, that were not discovered until later years, the presence on it of Désirade cannot be taken as positive proof that he saw or mapped that island in 1493. His outline of Guadeloupe is remarkably correct. But the mountainous character of the first island seen from the Admiral's ship, which was presumably at the head of the fleet, and the rest of Chanca's description stamp the north end of Dominica as the official landfall. Désirade has an elevation of only 919 feet (West Indies Pilot, Vol. 2, 1920, p. 248), and Marie Galante with a zero visibility of 31 miles could probably not be seen from the south end of Dominica.

Dominica to Guadeloupe

With the increase of daylight other islands came into view, six in all, most of them very large (Navarrete, Vol. 1, p. 200). These six[10]

[9] G. F. de Oviedo y Valdés: La historia general de las Indias, Seville, 1535, Bk. 2, Ch. 8.

[10] Mr. Jane (*op. cit.*, p. 23, footnote 4) suggests that possibly peaks on one island were taken to be different islands, an explanation advanced by Cronau and Stewart in discussing the first voyage (compare Glenn Stewart: San Salvador Island to Cuba: A Cruise in the Track of Columbus, *Geogr. Rev.*, Vol. 21, 1931, pp. 124–130).—EDIT. NOTE.

were Dominica, Marie Galante, possibly Guadeloupe,[11] and two or more of the Saintes (three of which appear faintly, unnamed, on the La Cosa map but are not mentioned in the narrative). It is possible that Martinique too was seen (*asension* on the La Cosa map, drawn much smaller than Dominica). No others were high enough to be visible from the caravels as they floated between Dominica and Marie Galante. La Desseada (Désirade) does not seem to have been one of the six islands reported by Chanca. The modern Antigua with a zero visibility of 44 miles could not be seen even from Désirade, and moreover it is not on the La Cosa map. The "Derrotero de las Islas Antillas" (Madrid, 1849, p. 41) says it "could be seen" from 10 leagues at sea, which means not more than 35 nautical miles.

The fleet first approached Dominica and sailed more than a league along it without finding a landing place. The "West Indies Pilot" (Vol. 2, 1920, p. 229) says that from Cape Melvill, also called Capucin, the western point of the northern extremity of the island, eastward to point Jaquet, the coast is a bold and lofty cliff, about 1000 feet in height near the center, . . . and maintains its rugged character to the southeast for about three and a half miles. The caravels then went across to Marie Galante "4 or 5 leagues" and the next day to Guadeloupe. The same authority says of Désirade that "the greater part of the south-east coast is fringed by coral reefs to a distance of a quarter of a mile (p. 248)."

Up to the time when the fleet left Guadeloupe there is no difference in geographic detai s between the narratives of Chanca, Martyr, and Fernando. Chanca got his geography from personal observation. Other data, on the islands and the people, he got mostly from women taken on Guadeloupe, some of them natives of that island and others held there in captivity who begged to be taken on board the caravels and delivered from their cannibal masters. These details, as a whole, do not concern us here. One, however, serves to show, as we shall see later (Table I), the sort of incident that impressed itself on the members of the fleet and, inferentially, the source of some of the narratives. It was the brush with the Indian canoe, in which the occupants, men and women, showed such courage and intrepidity that they continued to shoot their arrows from the water after their canoe had been overturned. Even this incident is referred to different islands. Another item is the expression of haste to reach Hispaniola, which, mentioned in connection with the same island in all three narratives, can hardly be called a coincidence.

Leaving Guadeloupe

After an eight-day stay at Guadeloupe, on November 10 Columbus began his sail up the coast. According to Chanca, the caravels made

[11] Guadeloupe may have been obscured, for it is not noticed until the next day.

little progress the first day because of calms. About noon of November 11 they sighted an island, not very large, which he says was about 12 leagues from Guadeloupe. This figure is more or less elastic to fit the position on the course from which the measurement was estimated. The island could be none other than Montserrat, which is about 30 miles northwest from the north point of Guadeloupe and 3000 feet high, while the next nearest island is the modern Antigua, half as far again, only 1330 feet high, and not even theoretically visible from the first third of the distance between Guadeloupe and Montserrat. The Indian women on board said the island in sight had been depopulated and its inhabitants eaten by the Caribs. The fleet reached and sailed past it the same day without stopping and in the afternoon sighted Redonda, near which for fear of shoals Columbus anchored (?) for the night. According to the "West Indies Pilot" (Vol. 2, 1920, p. 284) "from about 3 miles north-northwest of Redonda a coral bank extends for about 7 miles in a northerly direction." The next morning early, November 12, there appeared another island which seemed very large. Navarrete in a footnote wrongly says this was Antigua. He evidently follows Fernando and, beginning with this error, makes a succession of mistaken identifications.

The Nevis-St. Christopher Group

What island must this large one be? From Columbus' anchorage near Redonda, Boggy Peak, the highest part of Antigua, is 28 miles to the east, with a zero visibility of 44 miles and a probable visibility of only 35. Per contra, the position of the fleet, if we may infer that it was near the coral bank, was not much over 13 miles from *S. martin* (Nevis), whose zero visibility for two of its lesser peaks (1432 and 2350 feet) would be 46 and 58 miles respectively—not to mention the summit of the island, which is 3596 feet high (although "seldom visible").[12] From Columbus' position near Redonda, therefore, 13 miles away, any peak on Nevis that was only 121 feet high would have a zero visibility for him. Of the two peaks named, some 1312 and 2229 feet of their masses would be visible as against a possible 543 feet for Antigua. Reminding the reader again that the modern Antigua is not on the La Cosa map and that only one island is mentioned as in sight from near Redonda, we must believe that the island seen could be none other than the *S. martin* of La Cosa, or one of the Nevis-St. Christopher complex, at the northwest, on the general course the fleet was following to reach Hispaniola (F. C., p. 97).[13]

[12] Mt. Misery on St. Christopher (4313 feet high) was about 30 miles from Columbus' position and probably hidden behind Nevis.

[13] It is noteworthy that Drake and Hawkins (c. 1594?) on their passage over the route followed by Columbus on his second voyage through the Antilles, make no mention of Antigua (Hakluyt, Voyages, Vol. 7, p. 185, Masefield edit.).

Peter Martyr, who in his text places Montserrat, Redonda, and *S. martin* by name correctly according to the La Cosa sequence and is the only one of the cited authors to do so, adds some details that go to confirm the above inference and to identify the next island, the modern St. Christopher. He says that after having passed "saint Martin," on the next day Columbus saw an island with a long east and west coast line—which they called Antigua (Gaf., p. 26). After having passed Nevis, if on its east side, Columbus would be 40 miles from the modern Antigua and still farther if he passed it on the west. The mention of the long coast line fits St. Christopher. Antigua's actual diameter north and south (i. e. as seen from the direction of Nevis) is only 10 miles, whereas Fernando says the island sighted had more than 18 leagues of coast (F. C., p. 97), and Martyr says it had 150 "mille pas."[14] St. Christopher is actually 18 miles long, but its estimated (and comparative) length identifies the description positively with Martyr's "Antigua," not with the modern island of that name. In these early narratives the distances are often exaggerated.

The next island named west of *S. martin* on the La Cosa map is *la gorda*, (a part of) the modern St. Christopher. None of the writers heretofore quoted, not even Martyr, takes any notice of this name. It is very legible and must have been disregarded by design. Chanca gives no names.

Next west of *la gorda* is an island on the La Cosa map marked *S del an(te)bo* (?), the letters all plain except the two in parenthesis. This name is not on either of the Walckenaer copies, and is interpreted on the Jomard copy as *S. delanrebe*. To discern *antigua*[15] or *antigo* in *antebo* may involve too high a flight of imagination, but it seems to give the only possible explanation of Martyr's use of a name that had not already been assigned to any other island in the Antilles.

Gorda and Antigua are associated in a passage[16] which says that two caravels that came to Hispaniola with Bobadilla in August, 1500, were the *Gorda* and the *Antigua*. This was probably before the La Cosa map was finished. The Master of the *Gorda* was Andrés Martin de la Gorda. This, of course, was nearly six years after the voyage under consideration—perhaps too far away to serve as proof of the application in 1493 of three of those names to contiguous islands on the La Cosa map; but, when we reflect that a mariner of experience would probably be chosen to convey Bobadilla, it is not improbable

[14] According to Martyr 4000 pas = 1 nautical league (Spanish), and 3000 pas = 1 terrestrial league (Gaf., p. 216); also, 1 league = 4 miles (*ibid.*, p. 7).

[15] Antigua first comes on to the map (Reinel) in 1516, as *antigoa;* in 1523 (Turin-Spanish, Stevenson Collection, No. 6) it is Lantigua and later in the century becomes almost unrecognizable as *Planigoa* (A. E. Nordenskiöld: Periplus, p. 183). An island in its position is called *y. de sorana* on the Canerio map (1502) and on the Ptolemy of 1513 and 1525. Antigua was probably not known, as such, to the map makers in 1511 when Martyr's first authorized edition was published.

Curiously enough the island Redonda is found spelled *redonba* on the Wolfenbüttel-Spanish map (E. L. Stevenson: Maps Illustrating Early Discovery, etc., New Brunswick, N. J., 1906, No. 6).

[16] Bartolomé de las Casas: Historia de las Indias (5 vols., Madrid, 1875–76), Vol. 2, p. 477.

that Gorda had already been in the West Indies and may have been one of the seventeen commanders under Columbus on the second voyage in 1493–1494. But the names need not have been applied until 1500. We can at least see here a possible source for the names. Why Martyr rejected *la gorda* I shall try to explain below.

And here I may also essay an explanation of some other things on the La Cosa map. The "West Indies Pilot" (Vol. 2, 1920, opp. p. 290) gives a view of St. Christopher, 115° true, 14 miles—or about northwest by west, which would be about the direction of Columbus' track, from which position La Cosa might easily have inferred the island to lie northeast by southwest, as he shows it. Besides, we have also to reckon with the change in magnetic variation above mentioned, which would account for 10 degrees of his error.

The same work says that St. Christopher is "nearly divided into two parts by a low neck of sand, not a quarter of a mile across, and, consequently, at only a short distance it appears as two islands, and at a greater distance from the eastward or westward the irregular hills at the south-east end will appear as several detached islets" (*ibid.*, p. 289). This seems to account for the two small islands on the La Cosa map, between *S. martin* and *la gorda*.

The last member of La Cosa's Nevis-St. Eustatius group, going west, is on all three copies of the map designated *S. χp̃obal*. A partial explanation for these apparent discrepancies is found in the "Derrotero de ias Islas Antillas" (*loc. cit.*, p. 62): "If there should appear to be at the west of St. Eustatius and near that island a small islet, one need not be confused, for it is the extreme northwestern end of St. Eustatius itself, and on a nearer approach to it one will see the land that unites it with the part to the southeast." But the application of the name St. Christobal to this islet is anomalous, so far at least as all other maps of the time are concerned. The bare peak Saba, 2820 feet high, "2¼ miles in average diameter, and steep-to" (West Indies Pilot, Vol. 2, 1920, p. 293), is not given by La Cosa nor recognized in the narratives, unless S χp̃obal be meant for it. Rochefort[17] says of it: "On croiroit à la voir de loin, que ce ne seroit qu' une roche." This may account for its omission by Chanca and La Cosa. We know from the above that the three islands of the Nevis-St. Christopher group are represented on the La Cosa map by six, of which the two small unnamed ones next west of *S. martin*, with *gorda* and *antebo* (?), constitute the modern St. Christopher. If the actual composition of this group was known to Martyr, he must have recognized the error of the map and must have had to make a choice between *gorda* and the other name by which to designate the one island, and in *antebo* he may have seen Antigua and given it the preference.

[17] César de Rochefort: Histoire naturelle et morale des Iles Antilles de l'Amérique, Rotterdam, 1658, p. 43.

From what I believe was St. Christopher (Martyr's "Antigua"), Martyr takes Columbus directly to St. Croix and later through the Virgin Islands. Other writers, misled by Martyr's "Antigua" and overlooking or misunderstanding his *S. martin*, take Columbus to Antigua, then to what is likely to be understood as the modern St. Martin,[18] and thence to St. Ursula or to St. Croix. A familiarity with the La Cosa map might have enabled them to avoid both errors.

Returning to the narrative of Dr. Chanca we read, after mention of the very large island (*S. martin;* Nevis) seen from Redonda; "in order to bring consolation to those who had been left in Hispaniola we did not touch at any of these islands"[19] (Navarrete, Vol. 1, p. 206)—by which islands he probably refers to Montserrat, Redonda, and *S. martin* (Nevis).

Chanca continues: "On the next day [Nov. 13] at the hour of eating [breakfast?] we reached another island, and it appeared to us to be very good." This was evidently the next island in order, St. Christopher, the *la gorda* of La Cosa, a Carib island according to the women from Guadeloupe. The "West Indies Pilot" says it was called "by its primitive inhabitants Liamuiga, or the fertile island," and this characterization seems to agree with the cultivation (*labranzas*) noticed on it.

St. Croix and the Virgin Islands

The Chanca narrative says that after a stay of six or seven hours at this island "we went towards some other land which came in sight[20] . . . "along its coast; it was a very extensive land but not continuous, for it consisted of more than forty islands and as many more islets, very lofty and most of them bare." These were the Virgin Islands, and Chanca says that although Columbus did not land there he sent ashore men in a light boat, who reported some deserted fishermen's houses. The Indians on board said the island was uninhabited.

This extensive archipelago appears on the La Cosa map as a central member surrounded by smaller ones within a dotted circle,

[18] On the Reinel map of 1516 (cf. Jean Denucé: Les origines de la cartographie portugaise et les cartes des Reinel, Ghent, 1908) *sam mtim* is probably meant for the modern St. Martin, crescent-shaped with the opening to the northwest, which with *S. vicente* (St. Bartholomew?) is placed too far south, as a northwest extension of the Nevis-St. Eustatius group. The same is true, in a less degree, where this pair of islands are *sa marti* and *S: bertolameu*, on the Portuguese Atlas Ricardiana (Konrad Kretschmer: Die Entdeckung Amerikas, Berlin, 1892, Pl. 37). *San min* next to *Estaxia* appears on the map of Angelus Eufreducius (1556, Kretschmer, Pl. 20).

The original *S. martin* (Nevis) appears as *S. marta* on the Egerton map of 1512–13 (reproduced in the *Geogr. Journ.*, Vol. 36, 1910, facing p. 128).

[19] It is significant of the possible source of the Martyr and Fernando narratives that these two authors, like Chanca, give voice to this desire for haste, each at St. Martin but each probably with a different island in mind.

[20] Navarrete, following Martyr, makes this St. Croix (p. 208, footnote 1), a conclusion not supported by the subsequent text.

MAP OF LA COSA	Dates etc. derived from CHANCA'S description	MARTYR (French text)	FERNANDO (Italian text)
S mj^{a}deguadalupe	Left Nov. 10	Guadeloupe [no date] (Need of haste expressed)	Guadalupe (Nov. 10)
S my^{a}demonsera	Nov. 11	Montserrat [Nov. 11]	Monserrato
[Redonda] shown but not named	Nov. 11 (p.m.) Nov. 12 (a.m.)	Rotonda [Nov. 12]	Rotonda
S martin [Nevis]	Sighted Nov. 12 (Need of haste expressed)	Saint Martin [Nevis] (Need of haste expressed)	Antigua (More than 18 leagues of coast)
* Two small unnamed islands			
* la gorda (a long island) [St. Christopher]	Nov. 13 (hour of eating; very good; 6 or 7 hours; capture of Indian canoe)	Antigoa [part of St. Christopher]; "150000 pas" E-W. [Nov. 13]	S. Martino (Nov. 13) (Capture of Indian canoe; need of haste expressed)
* S delan(te)bo S χ̃obal [St. Eustatius]		"plusieurs iles"	
S. cruz / Las Virgenes	(Between St. Croix and Virgin Ids. Nov. 13, p.m. and Nov. 14)	Sainte-Croix [Nov. 14 and 15] (Capture of Indian canoe)	More than 50 islands (Virgins) Santa Orsola
boriquen	Nov. 15 (p.m.) (Coasted *boriquen* 30 leagues Nov. 16; in port Nov. 17–18; sighted Española Nov. 19)	*Boriquen* (Porto Rico)	San Giovan Battista

* Parts of St. Christopher.

which would indicate an absence of very definite information about them at the time. Most of the elevations are too low to make these islands visible from a caravel sailing along the south side of St. Croix, but the Virgins and St. Croix must be plainly visible from the passage between them. This last island is on the La Cosa map and was evidently seen and named at the time. The fleet soon came in sight of Porto Rico and later reached Hispaniola.

Supplementary Sources

The following notes and excerpts are taken from sources mostly contemporary. The reader will judge for himself how far, if at all, they discredit or modify the Chanca narrative. The account by Nicolaus Syllacius, "De Insulis Meridiani atque Indici Maris Nuper Inventis," was first printed, probably at Pavia, soon after December 13, 1494.[21] The author derived his information in part from a Spaniard who made the second voyage with Columbus. His account of the itinerary is meager and not without errors that betray his geographical limitations.

Dominica, Marivolante (*sic*), and Guadeloupe are mentioned, but no particulars are given of the run between the latter and St. Croix, at which island the brush with the Indian canoe is located, as in Martyr.

Simone Verde, a Florentine merchant, wrote two letters, one to Piero Niccoli of Florence, May 10, 1494, and another to Mateo Cini of Venice, Jan. 2, 1498. They were based on information obtained by Verde from Torres, a pilot and master of equipage under Columbus, on the second voyage. These letters are published by Harrisse[22] with translation into French and with notes.

Verde says that he had talked with three persons returned on the twelve caravels, of whom one was their captain, a second was pilot, and the third a master of one of them. He protests that what he is about to relate is only that part of what he had heard that he believes to be true.

Disregarding a logical order in his recital, he begins the letter by saying that, after they had left the cannibal island first visited, they found other natives of the same race, who went about on the water in barks made of hollow logs, impelled by paddles. Here he relates the brush with the Indian canoe; speaks of certain women held in slavery, who came to the caravels; and of the treatment of captives, etc., much as one finds stated in the Chanca narrative.

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[21] Reprinted, New York, 1860, with a translation into English by the Rev. John Mulligan. R. H. Major's translation of the Chanca letter from the "Select Letters of Christopher Columbus" . . . *Hakluyt Soc. Publs.*, Ser. 1, Vol. 2, London, 1847, is included here as an appendix. See also Amadio Ronchini: Intorno ad un rarissimo opuscolo di Niccolo Scillacio, Modena, 1856.

[22] *Op. cit.*, Vol. 2, pp. 68–78 and 93–101.

Perhaps the next paragraph is taken from a different letter. He says that after three weeks on the ocean the fleet arrived at the island of the cannibals, remained there some days, and left in search of Hispaniola. Sailing with one island or another constantly in sight, they found a large one like "Cicilia," they said, and went on shore. Not far away they found a very large and beautiful house unoccupied, and they fancied that at certain times of the year some great man came there for the pleasure of dwelling in it. Other habitations or people they did not see. They appear to have made only two landings. Then they arrived at Hispaniola.

This account is well-nigh inaccessible, and its importance may have been exaggerated. It confirms what appears to have been the chief incident of the voyage, as related by the other chroniclers, but adds nothing to our knowledge of Columbus' itinerary.

It has already been noted (footnote 4) that the first decade of Peter Martyr's "History of the New World" was surreptitiously used in a work printed in 1504.[23]

After describing the native dwellings in Guadeloupe the "Libretto" continues:

> And they left this Guadaluppa to go and find their companions at the island of Spagnola. In the first journey they left at the right hand and at the left many islands. There appeared to them at the north a large island which those people whom the Admiral had brought with him from the island of Spagnola and who knew how to speak, and those who had been recovered from the hands of the cannibals, said was called Matinina; . . . Sailing from sight of this island fifty miles, they passed another island which the aforesaid people from the island of Spagnola said was very thickly populated and had an abundance of all the things necessary to human life: and that it was full of high mountains. They gave it the name of Monferato . . . The following day they discovered another island, which because of being round in shape the Admiral called Sancta Maria Rotunda. Another farther on he called San Martino. But they stopped in none of these. The third day they found another which they judged to be near cl miles long in diameter from east to west along the coast. The interpreters of the country affirmed these islands to be all of a marvellous beauty and fertility. And this last they called Sancta Maria Antiqua. Afterwards they found very many islands; but cccc miles from there, one larger than all the others, which is called by the inhabitants Ay Ay: and our people called it Sancta Croce.

There follows the incident of the canoe and then the description of the journey among the Virgin Islands.

Oviedo in his "La historia general de las Indias" (1535) says that the first land found and recognized by Columbus was la desseada (Désirade), the next Marigalante, and he names all the islands in that area from north to south. Oviedo then lists a number of islands

[23] Libretto De Tutta La Navigatione De Re De Spagna De le Isole Et Terreni Novamente Trovati, Stampado in Venesia per Albertino Vercellese da Lisona a di x de aprile 1504. It has been reproduced by the Massachusetts Historical Society in the Americana Series, No. 30, 1930; and also, with an English translation, by J. B. Thacher: Christopher Columbus: His Life, His Works, His Remains . . . (2 vols., New York and London, 1903), Vol. 2, pp. 439–513. His translation (Vol. 2, p. 491) is used for the quotation that follows.

which, according to Chanca and La Cosa, Columbus could not have seen but finally clears away some of the confusion with the statement that Columbus saw only Desseada and some other islands which on his approach to the former could not fail of being seen, because of their proximity to each other. He does not mention Antigua and thus adds nothing authoritative to the subject under discussion.

Las Casas (*loc. cit.*) does not attempt to describe St. Christopher by name nor Antigua. Of the latter he merely says (after mention of Redonda) that Columbus *named* another island Antigua, which had 15 or 20 leagues of coast (thus following Martyr and Fernando) . . . that many other lofty and wooded islands appeared to the north, at one of which Columbus stopped and which he called "Saint Martin" (indicating the modern island of that name). His description follows closely that of Fernando, whose original manuscript he is said to have had in his hands.

Andrés Bernáldez, parish priest of Los Palacios near Seville, was a contemporary of Columbus and wrote of his voyages, narrating the second at length.[24] In that part with which we are concerned he follows the Chanca narrative so closely, almost word for word, that I have had no occasion to quote him.

[24] In "Historia de los Reyes Católicos D. Fernando y Da. Isabel" (2 vols., Seville, 1870), of which a manuscript copy is to be found in the W. C. Clements library.

References to printed editions of the work are given by Jane, *op. cit.*, p. cl, who includes in this volume the Spanish text and a translation of chapters 123–131 and in his new volume, "The Voyages of Christopher Columbus" (Argonaut Press, London, 1930), a translation of chapters 118 ff.—EDIT. NOTE.

AGRICULTURE IN THE UNITED STATES AND RUSSIA

A COMPARATIVE STUDY OF NATURAL CONDITIONS

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IN a paper published in the January number of this journal[1] a comparison was made of the potential capacity of the United States and Russia in the production of the kind of wheat that enters largely into the world's wheat market. It was shown that the geographic environments favorable to the production of this kind of wheat are confined to certain parts of each country and that in neither country can such wheat be grown throughout its area. It was shown that the United States and Russia both contain large areas of suitable land but that the area in Russia is much greater than that in the United States.

It would now seem desirable to compare the two countries in their potential capacity to produce other crops than wheat. The production of a few crops, even though the quantity produced may be great, does not promote the development of the varied and complex social and economic conditions characteristic of the most highly civilized of the great countries of modern times.

Both the United States and Russia taken as a whole are, unlike the countries of western Europe, dominantly continental rather than maritime. The influence of a maritime situation has long been the subject of discussion by geographers: the great continental areas have received less attention. Clearly the importance of the maritime region is due more to a favoring influence on commerce than on the production of commodities. While maritime regions cannot be neglected as producers of commodities, the history of the last half century has shown the capacity of the great continental areas to produce the staple agricultural products that are required by man in large quantity and that in turn demand large areas and productive soils.

Importance of Natural Environmental Regions in Agricultural Production

It is sometimes said that any crop may be grown anywhere at any time provided it be sufficiently protected. But the fact remains,

[1] Russia and the United States in the World's Wheat Market.

and it cannot be overemphasized, that agriculture is the one great productive industry that is still dependent almost entirely on natural conditions. The character of the agriculture, the extent of its development, and its relative importance are direct expressions of the natural environment; and a description of a country's environments is a description of that country's natural capacity for agricultural production. While man cannot be said to be entirely helpless in his efforts to modify the direct influence of the weather, the relief of the land, and the physical characteristics of the soil, his capacity to do so is very restricted. He has not created his crop plants. He has merely selected them and modified them within narrow limits. Most if not all plants still thrive best in environments similar to those in which they developed as natural plants. Man's efforts are limited merely to a strengthening of favorable natural factors and to the reduction of others—to allow nature to expend her whole effort on the particular plants he is growing rather than dissipate it on a great many plants with most of which he has no concern. Even though he may exercise this control, the mere fact of doing so increases the cost of producing his crops and to that extent places him at a disadvantage in the markets of the world where products produced mainly in favorable natural environments are placed on sale. In proportion, therefore, as his agriculture fits natural conditions the production cost of his crop, other things being equal, is reduced.

The great staple crops of the world—grain, forage, fiber, and oil—require total areas so large that man is wholly unable to perform the collossal work of modifying them even though he may be able to change a small area so as to produce some special crop in an unfavorable environment.

All things considered, the United States and Russia are more nearly alike in natural conditions and in potential capacity than any other two countries of the world. Both cover large areas, though Russia covers a much larger area than the United States. Both have large areas with similar or almost identical climate, natural vegetation, and soils. Especially significant is the existence in both of large areas of smooth plains.

The Natural Environmental Regions of the United States

In the United States there are twelve major natural agricultural environmental areas (Fig. 2). These may be described as (1) the Great Lakes Region, (2) the Mid-Latitude Region, (3) the Prairies, (4) the Southeastern Sandy Region, (5) the Mississippi Alluvial Belt, (6) the Northern Great Plains, (7) the Southern Great Plains, (8) the Dry Plains, (9) the Desert Plains, (10) Florida, Rio Grande, Texas, and the Far Southwest, (11) the Appalachians, (12) the Mountains of

FIG. 1—Natural agricultural regions of Russia.

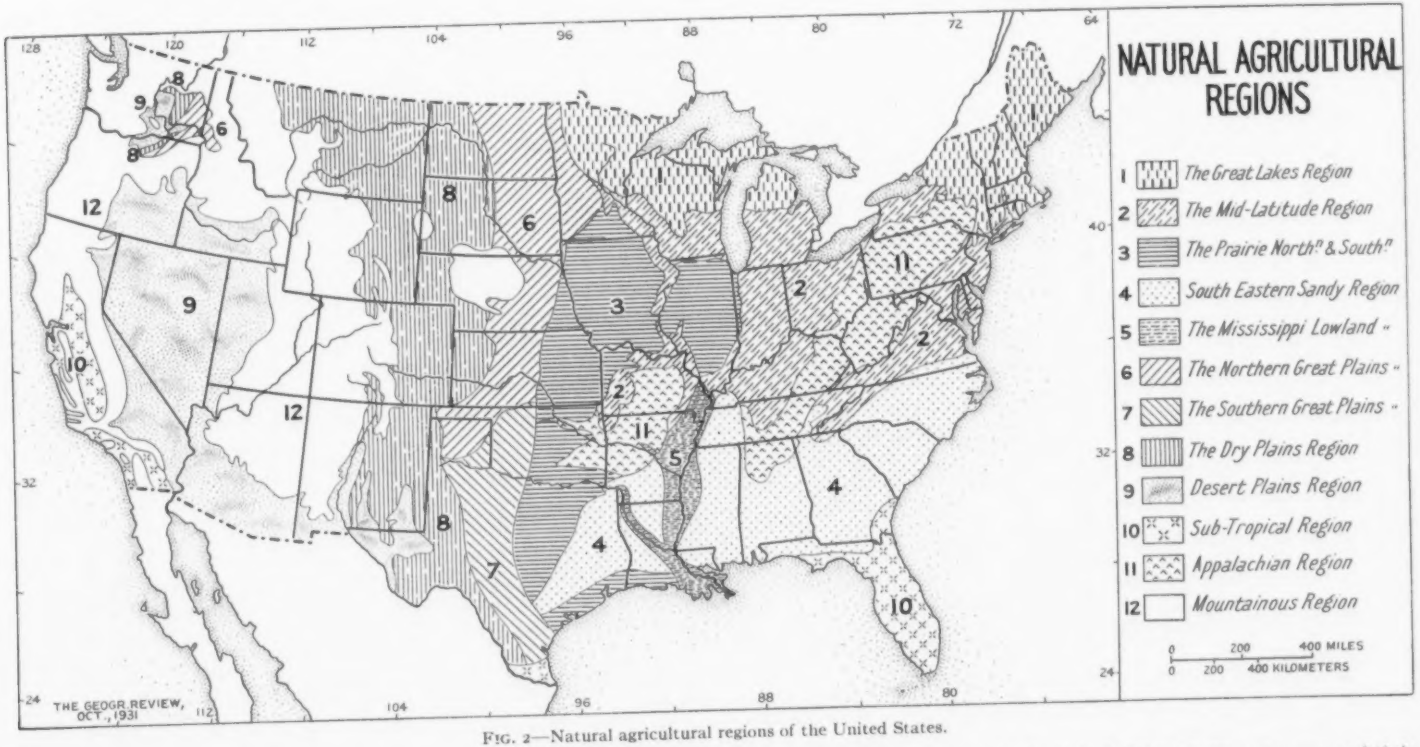
NATURAL AGRICULTURAL REGIONS
1 The Great Lakes Region
2 The Mid-Latitude Region
3 The Prairie North.n & South.n
4 South Eastern Sandy Region
5 The Mississippi Lowland "
6 The Northern Great Plains "
7 The Southern Great Plains "
8 The Dry Plains Region
9 Desert Plains Region
10 Sub-Tropical Region
11 Appalachian Region
12 Mountainous Region
0 200 400 MILES
0 200 400 KILOMETERS
128 120 112 104 96 88 80 72 64
40
32
24
THE GEOGR. REVIEW, OCT., 1931

FIG. 2—Natural agricultural regions of the United States.

Figures 1 and 2 are on the same scale, approximately 1:30,000,000. The natural agricultural regions recognized in the United States are more numerous and their distribution more complex than in Russia. Corresponding regions on the two maps are indicated by the use of the same numeral.

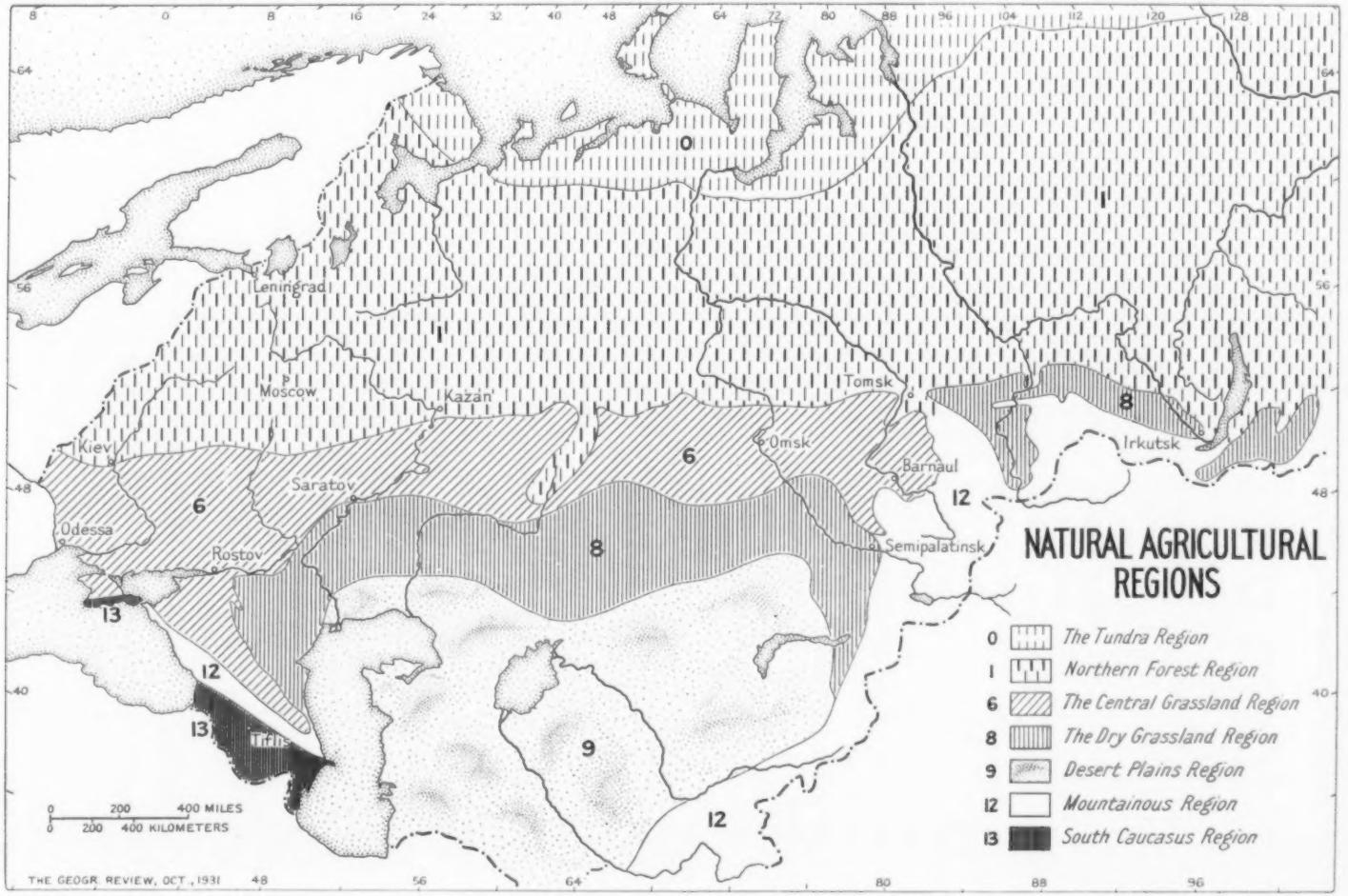

FIG. 1.—Natural agricultural regions of Russia.

the West. Most if not all of the environmental areas (I) to (II) inclusive exist within the mountainous area but only in many small areas, too small to be shown on a small-scale map.

The Great Lakes Region

The Great Lakes Region taken as a whole occupies a much larger area in Canada than in the United States. The humidity is high, the temperature low, the growing season short and cool. It is therefore not well adapted to the more desirable and higher-priced grain crops, and none of the fiber crops has ever been extensively grown in it. Cultivation is largely confined to forage crops, hay, and pasture, to the lower-priced short-season grain crops such as oats and rye, and to vegetables and small fruits. Considerable area is required to produce any considerable product. The soils are forest soils, poor, light in color, leached, low in organic matter, and of unfavorable structure. The livestock industry is devoted mainly to grazing rather than to the production of high-grade meats except through the importation of concentrates.

The Mid-Latitude Region

The Mid-Latitude Region is one of the most important from many points of view, including that of the development of agricultural wealth. Rainfall, temperature, and length of growing season are favorable to the production, with moderate care, of all the great crops that are produced in the moderately warm temperate zones of the world—grain and hay and all the minor crops, especially fruits and vegetables. The only important crop plant not now extensively produced in this region either in the United States or Europe is fiber, though the production of flax at one time was of importance.

The region, originally forested, is characterized by predominantly light-colored soils. They are somewhat more productive than those of the Great Lakes Region, having been developed under a cover of deciduous forests, the most effective of all types of forest in the eternal struggle of the plant against soil degradation. With fertilization they become moderately productive for a wide range of crops, though the dominant soil is not especially adapted to corn or to the highest quality of wheat. Over an important part of the region, however, there is a large aggregate acreage of dark-colored wet-land soils, now artificially drained, intricately distributed in small areas among the light-colored soils. They constitute the most naturally productive corn soils in the United States, giving to the region the possibility not merely of raising the types of livestock that are adapted to grazing but also of developing a livestock-feeding industry in which the highest quality of meats are produced. This industry in turn fits

exactly into the natural requirements of the dominant light-colored soil by furnishing an abundant supply of manures rich in fertilizing constituents cheaply produced without imported feed concentrates. No other part of the United States or of the world has a combination of factors so favorable to a richly varied and moderately productive agricultural life. The relatively large area required for a farm unit involves more or less isolation of the farmer and his family from his fellows and encourages individualism and independence. The necessity for careful management of the soils and for the maintenance of productivity through fertilization makes permanent residence on the land necessary and tends to develop stability in the population. It is a region in which the soil is capable of almost indefinite improvement. It is also equally important, or even more so, as a home for a relatively dense population. It is more nearly like the greater part of France, of south-central Germany, England, and Czechoslovakia than any other part of the United States and is that part on which the characteristic western-European type of civilization develops most naturally and readily. It is the type of country described by Ramann[2] as the natural habitat in which man develops the highest qualities of citizenship.

Highly mechanized agriculture in an area like this is relatively difficult, for it is not a one-crop country. Because of the great variety of crops the acreage of any one is necessarily small, and the capital investment in a great number and many kinds of large machines would be too great for economic profit.

The Prairies

The prairies form a region of dark-colored and highly productive soils. Soil character is strongly expressed and brings about an equally strong individuality in crop adaptation. The prairies, as compared with the soils of the region just described, are a one-crop region, but to a less extent than other environmental areas to be described below. The crop is corn. The character of the soils approaches that of the moist, recently drained dark-colored soils in the Mid-Latitude Region, whose suitability for the corn plant we have noted above but whose area is small compared with that of the prairies. The prairie region, therefore, is the Corn Belt of the United States, while the western part of the Mid-Latitude Region may be designated as the Little Corn Belt.

The Southern Subdivision of the Prairies

The southern subdivision of the prairies includes the belt extending southward from central Oklahoma into Texas. The northern part

[2] Emil Ramann: Der Einfluss des Bodens auf Siedelung und Staatenbildung und Kulturentwickelung, *Naturwissenschaftliche Wochenschrift*, Vol. 33, 1918, pp. 705–710.

of this belt, including the great black-land region of northern Texas, is a region in which the corn plant does well but where long growing season and relatively high temperature encourage its use for cotton. The poorly drained southern part lying along the Texan coast is used mainly for pasture, save where locally well drained. It is, however, a region of high potential productivity.

The Southeastern Sandy Region, the Cotton Belt

The Southeastern Sandy Region is the historic Cotton Belt of the United States. In general it includes that part of the United States where, on account of high temperature, high rainfall, and relatively sandy nature, leaching, or what may be called soil degradation, has been particularly effective. The soils developed under a tree cover and are naturally low in their content of organic matter, though their physical characteristics are favorable to plant growth. The region includes, however, the southern end of the Piedmont Region and the southern end of the great limestone valley of the Appalachians in which only part of the soils are sandy.

The cotton plant seems to have developed in a region of lower rainfall and more productive soils than those of the Southeastern Sandy Region; but, where fertilizers are supplied, the plant finds a relatively favorable environment because of the well drained nature of the soils and the relatively dry and warm weather of the late summer during which the plant is maturing. On the other hand this is not a region suitable for corn or grass: moderate yields of both may be obtained but only at the cost of a great deal of labor and materials.

The Mississippi Alluvial Belt

The Mississippi Alluvial Belt is given recognition because of large area and characteristic soils, other factors of the environment being essentially identical with those of adjacent regions. Its soils differ from those of other alluvial belts in that they contain a large proportion of material from the Great Plains, rich in fertile constituents. Mississippi alluvial soils are unleached and rich in organic matter. They constitute the largest if not the only important area in the world combining in such degree high natural productive capacity with high temperature and abundant moisture. The contrast between this environment with its possibilities and that of the environments in the midst of which it is placed seems to be greater than that between any other adjacent environments in any country. The importance of such relationships can hardly be overemphasized. The region is one of high productive capacity and wide range of adaptabilities, lying in the midst of a region where natural productive capacity is low and range of adaptabilities is narrow.

The Northern Great Plains

The Northern Great Plains are a region of fertile soils but light rainfall. The soils, as such, have within them the capacity to produce larger yields of the crops to which they are adapted and to maintain good yields for a longer time before becoming exhausted than any other soils within the United States. They contain high percentages of all of the normal constituents usually regarded as elements of soil fertility. Because of the light rainfall the region is not the most productive in the country, though the dryness is favorable to the high quality of the chief crop, wheat, and to ease of harvesting.

The Northern Great Plains are the great wheat-growing area of the United States. Previous to the last half of the nineteenth century lands of this kind, in the United States, Canada, Russia, Argentina, and Australia, where they occur in large areas, were used by nomads for grazing. The shift to wheat is the most important revolution in world agriculture that has ever taken place. Temporarily, at least, it has changed the anxiety of economists regarding the source of the world's bread supply to an anxiety as to what can be done with the wheat that is being produced. The world now has a surplus of wheat, and that surplus is due to the rapid placing into cultivation of the lands in this region in the United States and in similar areas elsewhere.

This region, with its large areas of smooth land of high natural productivity on which machinery can easily be used, is *par excellence* the region in which crops can be produced on a manufacturing basis, in which grain factories are possible, and hence large-scale capitalistic farming. Small farms, on the contrary, are handicapped by the likelihood of crop failures through drought. This contrasts completely with the Mid-Latitude Region in the natural capacity of the latter for producing moderate yields of a wide range of crops.

The Southern Great Plains

The boundary line between the Southern and Northern Great Plains is indefinite. Roughly it may be defined as the southern boundary of the dominant wheat-growing region, where the boundary line crosses northwestern Texas and Oklahoma, projected thence eastward across Oklahoma. The Southern Great Plains have soils only slightly less fertile, inherently, than those in the Northern Great Plains. They belong in the same general soil belt, but, lying in a more southerly latitude and enjoying warmer climate, their surface color is less dark; and, oxidation being more active, the subsoil is reddish.

In the northern part of the Southern Great Plains grain sorghums constitute the dominant crop, although grazing is important. The

southern part could be used for the growth of cotton throughout its whole extent, if the relief and depth of the soil were favorable. However, on the Edwards Plateau the soils are only about a foot deep or even less. Grazing is practically the only industry on the plateau, and even to the south of it much land is still used for grazing and will be so used for a long time. The region seems to be one in which the cotton plant finds a very favorable habitat. The fiber is of high quality, and except in seasons of very low rainfall the yields are good. The crop can be produced more cheaply than in the old southeastern cotton belt where the soils require fertilization and where also, because of rolling relief and severe soil erosion, the use of machinery is difficult.

The Dry Plains

West of the belt of the Northern and Southern Great Plains lies the region designated as the Dry Plains. Here, because of moderately good grass cover, grazing is feasible; because of normally low rainfall, crop growing is risky. In the Northern Great Plains, while yields fluctuate greatly, complete failures are rare: on the Dry Plains, while wheat is still the grain crop best adapted to conditions, failures are relatively frequent. The farmer must have other means of support than his grain crop. He finds this in livestock grazed on the range. A larger area is therefore required for the support of the family[3] than in the Northern Great Plains.

South of the New Mexico line only little wheat is grown in this belt, or a much lower proportional acreage than in the northern belt: grazing is practically the only industry.

The Desert Plains

The Desert Plains lie in general west of the Rocky Mountains and east of the Sierra Nevadas. They occupy the Great Basin, its northern extension in the state of Washington, and its southern extension in Arizona and New Mexico. The rainfall averages ten inches or less. Agriculture is not feasible except with irrigation.

Florida, Rio Grande, Texas, and the Far Southwest

Another important productive region consists of three separate relatively small areas. These may be described as the subtropical parts of the United States, for subtropical crops, mainly citrus fruits and winter vegetables, constitute the agricultural industry. In some of the regions or areas irrigation is necessary.

[3] Isaiah Bowman: Jordan Country, *Geogr. Rev.*, Vol. 21, 1931, pp. 22–55.

The Appalachians

The Appalachian region has been separated from the others not because it is inherently different in most of the factors of its environment but because it is rather strongly different in the topographic factor. Fertility and crop adaptation are not affected to a great extent, but the practical matter of crop growing influences the agricultural operations. On account of the rough topography crop growing as such has never been dominant. The region is primarily a grazing area, the soils and climate both being favorable to this form of utilization. Where smooth areas occur, however, they may be utilized in the same way as the greater part of the Mid-Latitude Region.

The Natural Environments of Russia

The map, Figure 1, shows the distribution of the natural environmental areas of European and Asiatic Russia defined on the basis of the criteria used in defining the areas in the United States in so far as available information makes it possible. If we describe the United States as a country in which the agricultural environment is somewhat complex, Russia may be described as a country with exactly opposite characteristics. The number of regions in Russia is smaller and the distribution simple.

The natural environmental regions of Russia, each designated by the same number as that used for the corresponding region of the United States when such exists, are: (0) the Tundra Region, (1) the Northern Forest Region, (6) the Central Grassland Region, (8) the Dry Grassland Region, (9) the Desert Plains Region, (12) Hilly and Mountainous Region, (13) the South Caucasus Region. The same statement may be made about (12) as was made about the corresponding region in the United States.

The Tundra Region

The Tundra cannot yet be considered as a region of significant agricultural production. Its characteristics are not well known, its population is of the sparsest, and for the purposes of this paper it may be left out of consideration.

The Northern Forest Region

The Northern Forest Region corresponds essentially to the Great Lakes Region in the United States, with which the greater part of it is identical in adaptabilities and productive capacity. On account of its very large area, however, it is much more important in its proportional influence in Russia than is the Great Lakes Region in the United States.

This region stretches eastward across European and Asiatic Russia from the western boundary of the country to the Pacific. Its trend is parallel to the distribution belts of uniform rainfall and temperature. As the width, however, is great, the southern part of the belt is necessarily different from the northern. The dominant characteristics of the Great Lakes Region in the United States are more extremely developed in the northern part of the belt in Russia than in the United States. Southward, however, the temperature is higher, and the growing season longer and warmer. Unlike the United States rainfall decreases southward also, so that before a climate comparable to that of the Mid-Latitude Region of the United States is reached the rainfall has become low and the environment changes to that of the Central Grassland Belt. A strip along the southern part of the belt, however, becomes somewhat like small parts of the northern belt of the Mid-Latitude Region in the United States, mainly that in Minnesota, central Michigan, and Wisconsin, though in the latter the moisture supply seems to be more favorable than in Russia. None of this belt, however, is used for the production of corn or of wheat. Corn is not used for silage, an important factor in the dairy industry in the United States, though it is not yet certain that it cannot be grown for this purpose; but corn growing as an important industry seems to be impossible. The large area of wheatland in the Central Grassland Belt makes the production of wheat in any part of the Northern Forest Region impracticable even though natural conditions permitted it.

The climate is too severe for the easy and cheap production of the wide range of fruits and vegetables characteristic of the Mid-Latitude Region of the United States.

The northern part of the region in the planning for the Five Year Plan is designated as the Forest Belt, being recognized by the Russians as unfavorable for agriculture. Its southern boundary runs from Leningrad eastward; but, because of the increasing influence of the continental climate in this direction, it runs slightly southeastward approximately along the 58th degree of latitude across Siberia to Lake Baikal. That part lying south of this line and north of a line through Moscow, from Minsk to the Urals east of Kazan, is designated as a flax-and-dairy belt. It covers an area of not less than 240,000 square miles and could produce large quantities of dairy products. Its features are especially favorable to such an industry, and when associated with fiber flax it becomes highly important.

Because other natural regions of Russia are not especially adapted to the livestock industry, especially to dairying, this region will be important for the purpose. It is not so well adapted to this, however, as the Mid-Latitude Region of the United States, because it does not grow the valuable grains. The cost of concentrates demanded

for feed in intensive dairying will be greater, other things being equal, than in the United States.

In Siberia the Forest Belt is broad and leaves only a narrow strip between its southern boundary and the southern boundary of the Northern Forest Region as here defined. This the Russians designate as a forest-and-flax belt. It may be used for dairying also when transportation and markets have developed. The southern part of the Northern Forest Region in European Russia is the industrial crops belt of the planning commissions. It will be described further on.

The Central and Dry Grassland Regions

These two regions occupy an east-west belt covering an area of nearly a million square miles in European and Asiatic Russia, an area between seven and eight times as large as the area of the corresponding portion of the Great Plains of the United States, and having the same inherent capacities for production. It is primarily a wheat region and the region in which, under the Five Year Plan, the attempt to increase production is being carried on with great energy. There seems to be no doubt that total wheat production can be greatly increased if the natural capacity of the region be fully or even moderately utilized. The area is large, and the adaptability of the region to cheap production of high-quality wheat in very large quantities is well-nigh perfect. As living conditions in Russia improve, much more grain will be consumed by her own population. This will come about not merely, however, because of improvement in living conditions but also because of her rapid increase in population. An increase of a million and a half a year necessitates a considerable increase in the production of bread each year. Yet the capacity for wheat production in Russia is so great that the period when she will have to import grain lies a long distance ahead. In the meantime the only reason why she may not export large quantities of high-grade wheat will lie in human rather than natural lack of capacity.

This region as a whole corresponds to the Northern and Central Great Plains of the United States. The northern part of the belt in Russia is the most important for wheat production, just as in the United States the eastern part is most important. The southern part of this belt, that part designated as (8) on the accompanying Russian map, is the region of chestnut brown soils, corresponding to the western part of the Great Plains Region in the United States. Wheat is not only the dominant crop but almost the only planted crop that can be produced, the quality being like that produced in the rest of the belt; but yields are normally low, and failures are liable to happen with relative frequency. A failure in the larger part of this belt of three or four crops in ten is not considered excessive.

The area of such land, however, is very large. It lies on great smooth plains and can be prepared for seeding very cheaply by the use of machines, and the crop can be harvested equally cheaply. It is a region in which wheat can be grown at a very low cost, but it is apparently no more favorable in this respect to the growth of low-cost wheat crops than is most of the black-soil part of the belt.

The natural vegetative cover in this region was grass. Almost all of the northern part is now in cultivation. The southern part, like the corresponding dry part of the Great Plains in the United States, still has large areas in natural grass and is used for grazing.

The Desert Region

This region is like the desert region of the United States. It is not productive without irrigation except for very poor grazing. Irrigation has been carried on for centuries along the southern part of the Turkestan desert.

The Southern Caucasus and Southern Crimea

This is a region of general dry and irrigated farming with a climate adapted to warm temperate fruits and the more hardy subtropical temperate fruits. Many of the fruits that have spread all over the world originated here. That part of the area with the most stable climate and the greatest freedom from frost lies around the southeastern end of the Black Sea and on the short steep slopes facing the sea in the southern Crimea. The latter may be considered as Mediterranean Russia. Even in the small area adjacent to the southeastern part of the Black Sea frost occurs with sufficient frequency to prohibit the growing of subtropical crops on a commercial scale. This is the region, however, in which tea growing seems to be practical. Some large plantations have already been established. The region is not equivalent to the California-Florida-South Texas region.

The Industrial Crop Belt

This is a belt outlined by the Russian Planning Commission, but it is not a natural region. It is confined to European Russia excepting an area in the extreme eastern part of Siberia and another in Turkestan. The most important by far is the European area. It covers the southern fringe of the Northern Forest Region and the northern part of the Central Grassland Belt. It is about 350 miles wide along the Polish-Rumanian boundary and less than 100 miles wide on its eastern end along the Urals.

That part of it lying within the Northern Forest Region includes the region where it grades into the grassland and where the forests contain a considerable proportion of deciduous trees. Conditions

resemble those in central New York, central Michigan, and east-central Wisconsin.

That part of this strip lying within the Central Grassland Belt has conditions somewhat similar to those in southeastern North Dakota. Because of favorable distribution rather than of a high total rainfall, the moisture conditions approach those in the western part of the Corn Belt in Nebraska. The season is too short for corn. Although the region is well adapted to wheat, it can be used to grow crops that normally require more moisture and hence has been chosen for industrial crops—sugar beets, flax, hemp, soy beans, and sunflowers. It is well known that natural conditions are not perfectly adapted to any of these crops and that cost of production will be greater than in an environment better adapted to them; but, since no more favorable area is available, this must be used. Hemp, soy beans, and sunflowers will probably be more successful than sugar beets; but it is apparently the intention of the Russians to grow beets on a larger acreage than any of the other crops, possibly than any two of them. The opportunity for producing fats or oils is limited; there is no area suitable for such peanut growing as is carried on in the southeastern part of the United States nor for corn growing—for hog feed—such as is carried on in the Corn Belt; hence this dependence on soy beans and sunflowers.

Sugar beets are produced in the United States in a humid environment. From the Red River Valley eastward they are grown under naturally humid conditions, preference being given to the areas of dark-colored soils artificially drained of their original excessive moisture. These areas in the United States are important in Saginaw County in Michigan; and similar areas lie in Winnebago County in Wisconsin but are not extensively used for sugar beets. Beets are not extensively grown on the light-colored soils. It is apparent that the northern part of the industrial belt in Russia contains light-colored soils only. In the western part of the United States beets constitute an important crop entirely under irrigation. Irrigation is not possible, however, over large areas in Russia. Beets could doubtless be raised under irrigation in Turkestan, but space is preëmpted for the food crops demanded by the dense local population and for cotton, which can be produced nowhere else in the country. This leaves the Russians under the necessity of using the northern part of their black and brown soil belt in European Russia for growing beets. It would be equivalent to growing them in eastern North Dakota; and it is well known that, although it is possible to grow them in this region, the yield is very low.

Summary

The most striking difference between natural conditions for agriculture in Russia and the United States is the simplicity of the former

and the complexity of the latter. Russia has nothing corresponding to three of the most productive regions of the United States—the Mid-Latitude Region, the Corn Belt, and the Cotton Belt, all of which have been of tremendous importance in the production of the agricultural wealth of the United States. The most important of these regions, and the one that has inherently the greatest capacity for production though not necessarily the greatest capacity for supporting a large agricultural population, is the Corn Belt. It is peculiarly adapted to the corn plant, and it is the only large area in the world that is so adapted. Russia produces corn but at a disadvantage. She regards a yield of 25 or 30 bushels of corn as good. The farmer in the Corn Belt using ordinary or cheap methods of production regards a yield of 50 bushels as only fair and a yield of 60 to 70 bushels as good.

Russia has no considerable area of dark-colored originally wet lands corresponding to the American Little Corn Belt. The nearest approach to such lands are those lying along the northern border of the Central Grassland Belt in European Russia, which have been set aside for industrial crops. It is apparent that Russian plans do not contemplate the production of corn in this region, though it is better adapted to the growth of that crop than is the region where the crop is now grown. While some corn is grown in all parts of the black-earth region, especially in European Russia, yet the greater part of it is grown in the southern part of Ukraine and in the Crimean region where the soils are sandy and where such rainfall as is received is conserved by the sandy soil.

In connection with the great Mid-Latitude Region of the United States attention should be called to the fact that Russia not only from the economic standpoint but also from the social standpoint has nothing comparable to it.

The third important region of the United States to which nothing corresponds in Russia is the old Cotton Belt. In the past it has been of great importance in the economic development of the United States and will so be in the future, although at present it is relatively less important. It is apparent that, under proper methods and by the use of intelligence in growing the kind of cotton in demand, the product of the southeastern part of the United States cannot well be driven from the world's market. Russia is at a great disadvantage as compared with the United States in this respect. She has no area where cotton can be grown as cheaply as in the southeastern part of the United States, and the area capable of growing cotton at all is relatively small even under the ambitious plans for irrigation in Turkestan.

In variety of products Russia therefore stands, as compared with the United States, at a great disadvantage. In capacity to produce a few crops in large quantities at low cost—primarily wheat—the United States suffers a great disadvantage as compared with Russia.

INDIGENOUS IRRIGATION WORKS IN PENINSULAR INDIA

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WHEN we think of irrigation in India we do so primarily in terms of her wonderful network of great canals, triumphs of which modern engineering is justly proud. This is natural enough, yet it remains true that in any year more than half the area irrigated in India derives such nourishment from a variety of small, humble works, the great majority of which are constructed and maintained by the cultivators themselves with or without assistance from the authorities.[1] The water supply of these petty undertakings is often uncertain; and this, together with other considerations, causes the number in use and the area served by them to fluctuate rather widely from one year to another. After a series of good rainy seasons, many waterworks are likely to be found in disrepair from neglect; during a run of bad seasons the number of works of a type that can be usefully resorted to under such circumstances shows an increase. Several are of a temporary character and must be abandoned after a season or two.

In contradistinction to the level alluvial expanse of the Indo-Gangetic Plain, traversed and *watered* by rivers sustained from the snow fields and glaciers of the Himalayas, Peninsular India, which makes up the rest of India proper to the south, is essentially an undulating upland of hard old rocks *drained* by rivers entirely dependent upon a markedly seasonal rainfall. Unlike the Indo-Gangetic Plain, the Peninsula offers few facilities for irrigation on a grand scale. Hence, while small works are most important on the northern lowland, in the Peninsula they are, over the greater part of the whole, the *only* protection against a notoriously fickle rainfall.[2]

As dictated primarily by the physical ground plan of the Peninsula, the most generally characteristic irrigation work is one designed to store surface water. The term "storage work" covers at one extremity the huge modern reservoirs constructed in the upper reaches of certain of the larger rivers that rise in the Western Ghats and are subjected

[1] The Report of the Royal Commission on Agriculture in India (Cmd. 3132, London, 1928), pp. 338–339, emphasizes the fundamental importance of these small works and urges Government to devote more attention to them.

[2] A. V. Williamson and K. G. T. Clark: The Variability of the Annual Rainfall of India, *Quart. Journ. Royal Meteorol. Soc.*, Vol. 57, 1931, pp. 43–56. See the note in the Record section of this number of the *Geographical Review*.

to reliable heavy floods during the southwest monsoon season every year and, at the other extremity, the tank. The same principles underlie both, fundamentally the same problems are common to both, and in a measure they suffer from similar disadvantages. The great distinction is that one is an unfailing source of water, the other is not, though it is true that some tanks are really large works with a supply that fails seriously only at rare intervals.

Irrigation by Tanks

Typically the tank is a modest affair consisting of an earthern embankment, *bund*, blocking the line of a stream or closing the outlet of a natural depression in which rain collects; in places it may take the form of a hollow in the ground fed by a channel cut from a neighboring stream. Sometimes a series of dams are placed across a valley so as to give a chain of tanks, the surplus from the higher feeding the lower. Such chains are particularly conspicuous across the valleys leading from the larger catchment areas of Mysore. Generally irrigation from tanks is by means of small cuts and channels through which the water flows onto the fields in the vicinity. Over a considerable area in the Central Provinces and Bihar, characterized by an "upland and basin" ground plan, the tanks are placed on the hill slopes, and the water they collect is allowed to soak through the subsoil into the cultivated fields below.

Advantages and Disadvantages of Tanks

The essential function of the tank is simply to correct the vicissitudes—the untimely distribution and abnormal downpours—of the rainfall of a given season and to husband it so that it may be used to best advantage; if the rain fails, then of course the tank fails. The content of the smaller and shallower tanks is usually completely exhausted during one crop season if not before, and the bed is dry before or at the close of it. Except for some tanks in those parts of the Peninsula, almost wholly in the extreme south, that are particularly favored by rainfall in the hot season (March to May), all are dry at this time. The soil of the tank bed naturally varies according to the nature of the surface of its catchment area; but there is often a good mantle of silt, which may retain sufficient moisture to enable a crop to be raised immediately after the tank bed becomes dry or may be used to graze cattle on. A temporary water supply may at times be tapped by a rude well dug in the bed. Even in the case of the largest tanks it is not the policy to attempt to hold over water from one year to the next in view of the heavy loss from evaporation during the hottest months of the year, in addition to leakage.

In some cases the area submerged by a tank and thus lost to

cultivation, temporarily at least, may be as much as one-quarter of the area irrigated by it. Another disadvantage is the accumulation of silt and consequent loss of capacity. This is said to be the principal reason for the decline in the area irrigated in the southern Mahratta

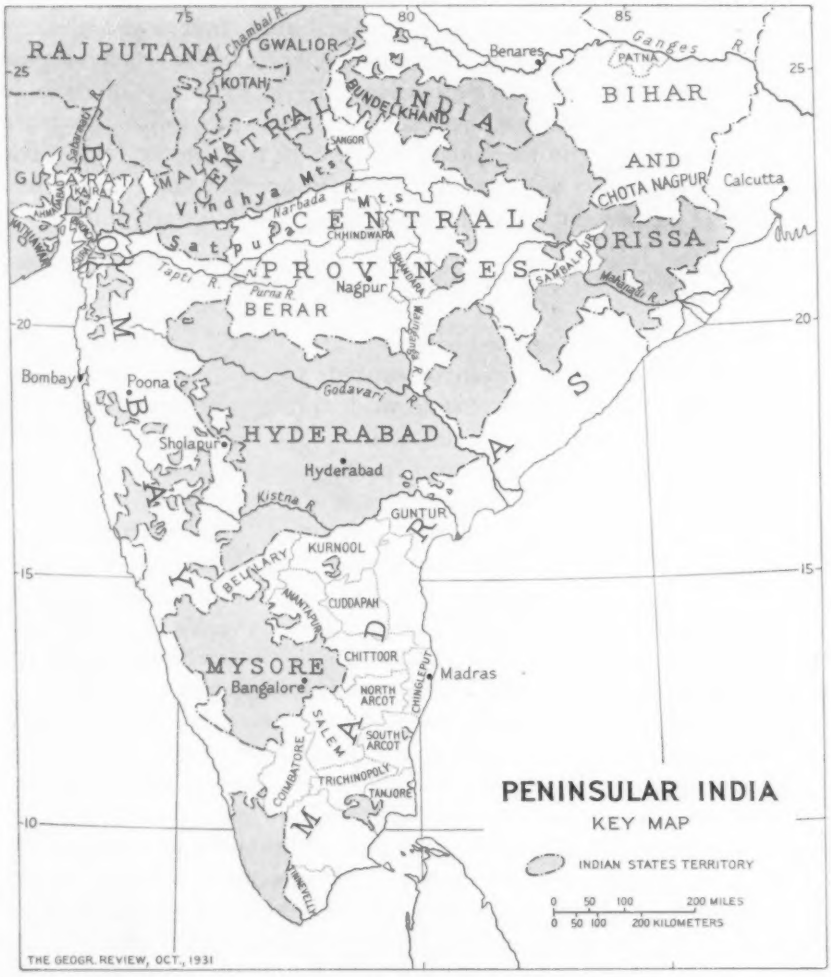

FIG. 1—Peninsular India. Key map to place names mentioned in the text. The dotted lines are boundaries of districts to which reference is made. Scale 1 : 16,500,000.

country during recent years. Tanks are also a frequent source of quarrel and litigation amongst those whose lands are affected by them.

However, apart from the fact that tanks are often the only practicable means of obtaining at least some measure of security, they are justified on the ground that, in the aggregate, they utilize a large volume of water that would otherwise run off the surface and be lost, particularly in small catchment areas. Furthermore, they

frequently occasion a rise in the subsoil water level in their immediate neighborhood and thus aid the extension of wells; three-quarters of the wells in Mysore and a large number of those in Madras are directly dependent upon tanks.

A rainfall régime that tends to foster the growth of a semi-aquatic crop such as rice, namely heavy seasonal rain, favors also the use of the tank, so that, next to the canal proper, it is the preferred type of irrigation work among rice cultivators. If there are appreciable downpours other than at one season of the year, as in the more southerly parts of the Peninsula, this is a further incentive to tank building; but such a work cannot be relied upon, save in rare cases, to support a perennial moisture-loving crop such as sugar cane.

The Black Cotton Soil

The parts of Peninsular India that are covered by black cotton soil (*regur*) form an important exception to the general statement that the tank is the characteristic work throughout the entire area. The facts concerning the origin, nature, and distribution of *regur* have become much better known in recent years and need not be reviewed here. Suffice to recall that it is a finely grained clay loam, calcareous and free of pebbles but containing rounded concretions cemented by carbonate of lime (*kankar*), and that it prevails in general throughout the area covered by the basaltic formation known as the Deccan Trap but is by no means limited to it. It varies in detail from place to place, but all definitely recognized varieties are highly retentive of moisture; it is often underlain by an impervious substratum.[3]

The retentivity of *regur*, the low and uncertain rainfall of the areas it is primarily associated with, and the fact that "dry" cultivation is traditional in these circumstances all help to explain why irrigation is at a minimum in such tracts. But certainly the main reason is that *regur* demands at best unusual care in the artificial application of water to it, and it is still a matter of controversy how far it can be guaranteed to respond successfully to irrigation.[4] There have been important contributions to this problem within recent years,[5] but the general conclusions arrived at by the Indian Irrigation Commission in 1903 have not been seriously challenged. The Commission stated, in brief, that only where such soil was not of great depth and rested on a substratum affording good natural drainage could irrigation

[3] See in particular H. Harrison and M. R. Sivah: Memoirs of Department of Agriculture, India, Chemical Series, Vol. 2, No. 5. They observe, p. 272: "Although possessing common agricultural characteristics (regur soils) are derived from many diverse rock formations and they are of comparatively local formation. It is evident, however, that very often they have not been formed in situ, but any transportation which may have taken place appears to have been confined to a limited area."

[4] Report cited in footnote 1, p. 72.

[5] See in particular C. C. Inglis and V. K. Gokhale: Soil and Subsoil Surveys in the Deccan Canal Areas, *Bombay P.W.D. Tech. Paper No. 13*, 1926.

be applied freely and with profit; that even in deeper soils rice could be advantageously irrigated; and that, under all circumstances of depth and subsoil, irrigation had a protective value in years of drought. They added that where *regur* is present as an alluvial deposit conditions seldom permit of irrigation.

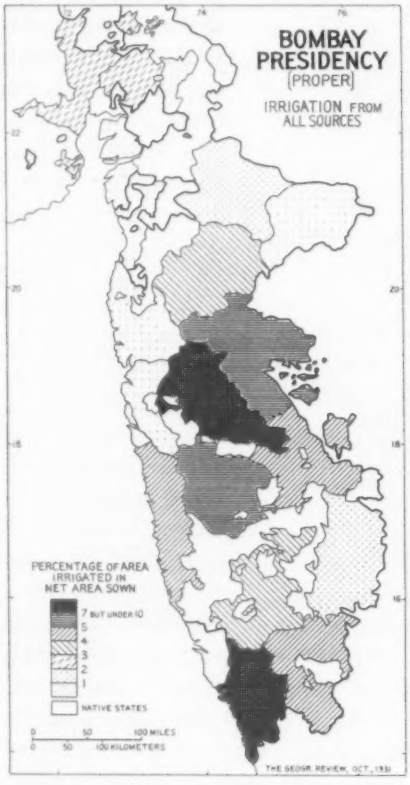

FIG. 2

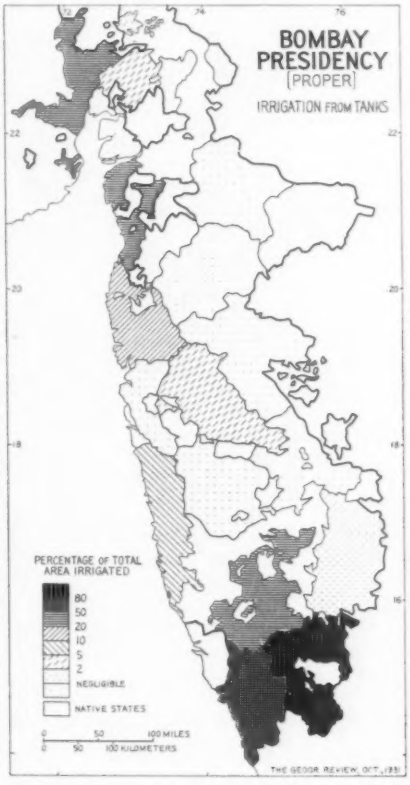

FIG. 3

FIG. 2—Map of Bombay Presidency (proper) showing extent of irrigation from all sources. No returns are available from Indian States territory, which is left blank. Scale 1:10,800,000.

FIG. 3—Map of Bombay Presidency (proper) showing proportion of irrigation from tanks. No returns are available from Indian States territory, which is left blank.

In so far as irrigation is practiced in black cotton-soil areas the preferred small work is the well. Several factors combine against the tank. Thus the soil itself performs, in some measure, the essential function of a tank in relation to the characteristic crops, namely cotton, wheat, and millets; while the rapidity with which the soil drys and cracks often renders it difficult to keep the surface flooded; to do so demands much water and labor. Hence *regur* seldom lends itself to rice. Over a large part of the trap country rainfall is meager and extremely fickle, and evaporation very high; this tends to dis-

courage the construction of tanks by the people themselves and to destroy their confidence in any that may be provided for them. Finally, the characteristic landscape resultant upon the weathering of the basalt sheets, namely flat-topped, steep-sided hills and at lower elevations extensive surfaces of a generally monotonous level seamed by gullies, does not assist the construction of petty storage works like the undulating face of the rest of the Peninsula as a whole.

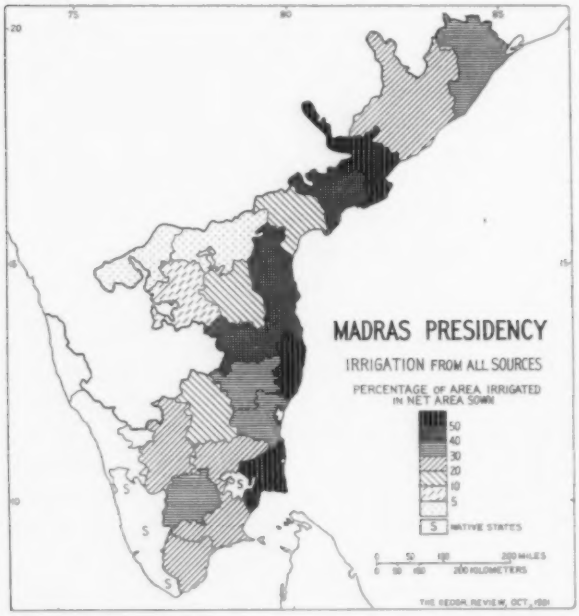

FIG. 4—Map of Madras Presidency showing extent of irrigation from all sources. No returns are available from Indian States territory (S). Scale 1 : 17,500,000.

AREAL DISTRIBUTION OF TANKS

The tank reaches its fullest development in Madras, where about 70,000 are recorded; of these, 50,000 serve less than 50 acres each, while the number in use at any time does not exceed half the total available. However, considered together the tanks in the Presidency nourish from 3 to 3½ million acres of land each year, an area rivaling that watered by the great deltaic and lesser canal systems. They play a leading part in every district of Madras outside the deltas, with the exception of Coimbatore where unusual facilities for well construction and a markedly low rainfall operate against their extension. In number and in the area they serve they are most conspicuous in the valleys opening out of the hill country of Chittoor and North Arcot and on the coastal lowland to the east lying between but outside the respective spheres of the Tanjore and Penner delta canal systems. Here humidity is high, rainfall appreciable, and of a pronounced storm character so that run-off is considerable. In the District of Chingleput, out of a total irrigated area amounting to two-thirds of the area sown, nearly 90 per cent is fed from tanks.

In Mysore, less endowed than Madras for the development of other forms of irrigation but enjoying a moderate rainfall well distributed through the greater part of the year, "red" soils that practically

everywhere respond excellently to water, and a most enlightened government, the rôle of the tank is paramount. It is said that the number available averages one for every three-quarters of a square mile of territory. The tank remains the chief source of irrigation in Hyderabad though artificial watering is not, as yet, well developed in the Nizam's dominions and is probably more completely absent from western Hyderabad than from any other black cotton soil area. The people of this tract have never made any attempt to undertake irrigation unaided, nor has their attitude towards any suggestion for its provision been an encouraging one even after famine visitations. Tanks, of which there are roughly 20,000 maintained by the Government alone, are restricted to the eastern division which enjoys a better rainfall and uses its "red" soils for the purpose. Of the large number of tanks recorded as available in the Central Provinces and Berar—nearly 50,000—more than half are in the Wainganga basin, where they cluster primarily in Bhandara; the remainder are found mainly in Chattisgarh, particularly in the Sambalpur area, where many are used primarily for domestic purposes and only at long intervals for irrigation. In Bihar and Orissa the largest area returned as under tanks is in the Patna district, sloping down northwards to the Ganges, but tanks are of greater relative importance in the hill country of Chota Nagpur, where there is little irrigation from any other type of work. Throughout the section of the Peninsula lying north of the Vindhyan escarpment, there is abundant evidence that irrigation of all kinds was far more extensively practiced in the past than it is today.[6] This area suffered severely during the many years of warfare that marked the decline of the

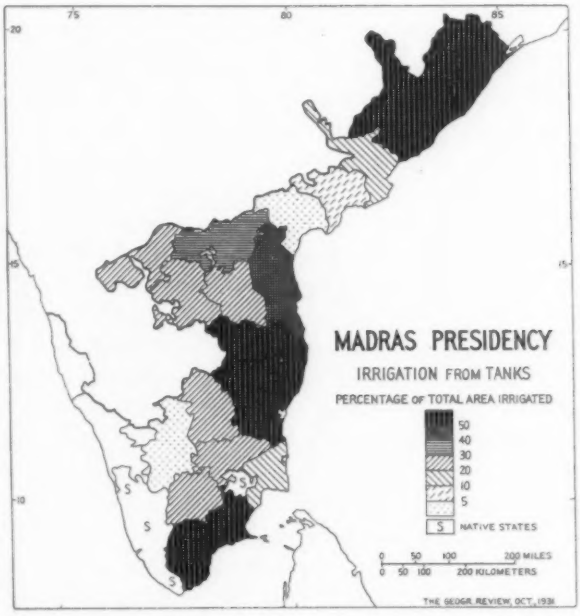

FIG. 5—Map of Madras Presidency showing proportion of irrigation from tanks. No returns are available from Indian States territory (S).

[6] H. Marsh: Protective Works in Central India, *Agric. Journ. of India*, Vol. 1, 1906, p. 290, and references there.

Mogul Empire and the establishment of effective British control, and the fragmentation of the whole into numerous states has tended to check recovery.

Embanking as a Means of Soil and Water Conservation

The embanking of fields and hillsides, though not ordinarily included under the head of irrigation works, plays an important part, whether undertaken primarily for such a purpose or not, in securing the benefits derivable from rainfall. Work of this nature is perhaps the most valuable instrument of conservation in the service of agriculture wherever this is carried on under a rainfall régime such as obtains in India. It has been remarked, not inaptly, that loss of water and of soil by heavy downpours constitutes the real "economic drain" in India. The most extensive areas of ravined land are in the hilly districts of the Central Provinces, Central India, and Bundelkhand, where shifting cultivation is a powerful factor aiding destruction. The higher western parts of the Deccan also come under heavy scour. It is not to be imagined, however, that damage of this kind is confined to areas of marked slope; it is often most serious in valley bottoms and basins where to the destruction wrought by torrents that have gathered strength on the higher slopes may be added ruin resultant from water-logging.

The typical embankment is of earth or stone or a mixture of these materials. In height it may be anything from one to ten feet and may run like a rampart along a hillside for a considerable distance. Because of their utility in so many directions embankments are employed by all careful cultivators throughout the length and breadth of India; but there remains considerable room for their extension, especially into the lower lands—those of the Deccan in particular. The moisture-retaining nature of *regur* renders embankments of especial value in association with such soil, particularly if it is devoted to *rabi* (spring) sowings, which is often the case. It is pertinent to add here that the rapid-drying and cracking properties of this soil reduce the liability of seed sown after the rainy season to suffer from lack of air. On the naturally well drained and only moderately deep black soil of the Upper Narbada basin, devoted preëminently to wheat, a *rabi* crop always, embankments as a means of irrigation are more conspicuous than anywhere else in India. They also occur fairly prominently on the similar wheatlands of Gwalior and British Bundelkhand. The embanking of black cotton soil is general in Madras and fairly common in the higher western parts of the Deccan but is rare in the lower lands to the east. The latter are at present largely dependent on *rabi* millets as the staple food crop; embankments might well permit raising of the more valuable wheat.

Well Irrigation

Considering India as a whole, irrigation under wells probably accounts for a quarter of the total area thus served. Unlike tanks, wells do not fail as soon as the rain stops: they can usually be relied upon through a single dry season, though only in rare cases do they function effectively if this is followed immediately by a second.

Under well irrigation the standard of cultivation in India reaches its highest level. Well water is costly, since it has to be lifted, often from considerable depth. The energy and time thus expended tend to economic use of the water, a circumstance that benefits the crop both directly and indirectly: directly, in that it is not so liable to suffer from being overdosed with water; indirectly, because the cultivator is likely to pay more attention to the construction of water channels, careful grading of the surface, and other operations, such as weeding and interculture, than he would do otherwise. And, a most important point, a well, at least one of a permanent nature, imposes a heavy capital outlay on the individual undertaking it, and this naturally fosters a more intensive form of cultivation than obtains under other circumstances.

Three-quarters of the area irrigated under wells in India lies on the Indo-Gangetic Lowland, where a hole a few feet deep, dug in the level alluvial floor and lined with brushwood, often suffices to tap a useful supply of water. This is especially true of the United Provinces, where the clay content of the soil is high. This province alone embraces nearly half of the area of India irrigated by wells, most of them being temporary wells like that just described, i.e. without any masonry reinforcement.[7]

In Peninsular India it is only on the alluvial lowland of Gujarat and the corresponding coastal plain of Madras, in the east, that conditions for wells in any way approximate those in Northern India; and this approximation, as will be shown, is more apparent than real. Over the Peninsula as a whole the run-off is rapid, there is only a shallow depth of unconsolidated material, and there is little contribution to the subsoil reservoir from rivers. The moisture that percolates through the surface layers passes down into the solid rock mainly through cracks and fissures, and water in useful quantity lies usually at thirty to forty feet and sometimes deeper.

Areal Distribution of Wells

In circumstances such as these well sinking is a hazardous undertaking, and in the most favored area, the valleys of the Western Deccan, the number of failures is estimated at 40 per cent. In areas

[7] A. V. Williamson: Irrigation in the Indo-Gangetic Plain, *Geogr. Journ.*, Vol. 65, 1925, pp. 141–153.

of metamorphic and crystalline rocks the risk is usually greater than in areas of trap rock, since the former are less fissured than the latter. With unimportant exceptions, the wells are necessarily permanent, being dug down into rock. This often demands blasting, which is expensive; but the material excavated serves to line the well as far as this is necessary, and such wells are on the whole cheaper to construct than wells in loose sand or gravel. In shape they are typically square and, in order that a maximum surface for percolation may be provided, are very wide, ranging up to as much as a hundred feet across the mouth.

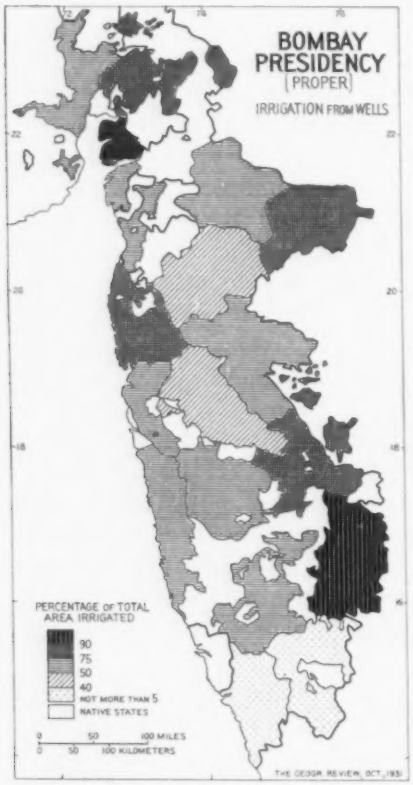

FIG. 6—Map of Bombay Presidency (proper) showing proportion of irrigation from wells. No returns are available from Indian States territory, which is left blank.

The alluvial deposit of the Peninsula, which is significantly developed only in Gujarat and Madras, is of much less depth than that of the Indo-Gangetic zone; its clay content is lower; and the valuable beds of this material found in the north are absent here.[8] The level of the water table is in general lower and more fluctuating. The wells are often brackish, particularly in Gujarat, and a shallow well of sweet water deepened to obtain a better supply is liable to become salt. This tendency is most marked in the water yielded by the deep *regur* alluvium of Broach, and it persists from thence up the valleys of the Narbada and Tapti rivers—arms of the sea in Tertiary times. However, wells, like all other forms of irrigation, are very scarce in these particular areas. Elsewhere in Gujarat, and more especially in the districts of Ahmadabad and Kaira which account for 80 per cent of the area irrigated by wells in this division of the Bombay Presidency, the alluvium is sandy and loose. The water table, except in Surat and along the Sabarmati River particularly, lies as deep as elsewhere in the Peninsula, so that careful masonry lining is necessary throughout. The average cost of sinking a well is probably higher

[8] *Ibid.*

in Gujarat than in any other part of India; but the soil responds excellently, and there are good markets in Bombay and other adjacent large urban centers. As usual in loose material, in contradistinction to solid rock, the well is circular. It may be added that the subsoil water level in Gujarat is reported to be falling; several large wells have dried up in recent years. The coastal lowland of Madras compares favorably with that of Gujarat; in general water lies closer to the surface, and in places there are good springs.

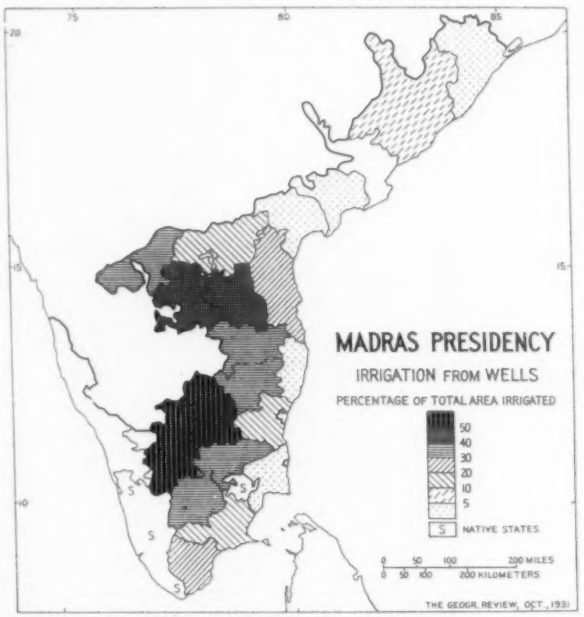

FIG. 7—Map of Madras Presidency showing proportion of irrigation from wells. No returns are available from Indian States territory (S).

CROPS WATERED FROM WELLS

The average well in the Deccan irrigates about two acres. The same is true for Gujarat. In Madras the corresponding area is about three and a half acres, and in Central India it is a little more. For the Peninsula as a whole it may be said that a permanent well serves on the average between two and three acres, which is about a quarter of the area served by a similar type of well on the Indo-Gangetic Plain. This, of course, reflects the difference between the crops that it pays to irrigate in the respective areas, the total quantity of water required by them, and the frequency of waterings necessary. To the fact that, in general, wells are more expensive to construct and more costly to operate must be added the fact that, on the average, a given quantity of water does not go so far in the Peninsula as in the well-irrigated zone of the Indo-Gangetic area, for temperature is more consistently high. In the former water is restricted largely to the crops that yield the highest profit per acre, such as sugar cane, betel vine, plantains, chillies, and other garden produce. These are typically heavy consumers of moisture and require water at frequent intervals. For example, sugar cane under wells in the Deccan, where the annual rainfall approaches 30 inches, is irrigated to an extent equal to 75 or

80 inches of rainfall, waterings being given at intervals of about four days in the hot season and eight in the cold season. Unlike Northern India, cereals and pulses occupy a place only at long intervals in a rotation; and, since irrigation by lift is, at best, not adapted to rice, the well at present plays only a minor part in typical rice tracts.

Although the area under wells in the Madras Presidency as a whole exceeds that of any other province or state in the Peninsula, it is not commensurate with the superior facilities which it enjoys. More than half of the well-irrigated area of the Presidency lies in Coimbatore, Salem, the Arcots, and Trichinopoly—Coimbatore alone embracing a quarter of the total. The latter district, in particular, is rich in springs; rice is noticeably unimportant, while the area is famous for its cotton and sugar cane. Elsewhere in Madras wells are classified mainly as "supplemental" to tanks, i.e. sunk in land commanded by the latter. In the delta areas and the Northern Circars along the east coast, a rice zone *par excellence* where wells are negligible despite the opportunities for them, they might well be introduced in addition to existing canals and tanks, both for the purpose of protecting rice at critical times and also in order to stimulate a more diversified and better type of farming. Rice growing itself represents a highly specialized technique and is particularly laborious work. But a single good harvest solves the food problem of a family for a year. The fact that the typical rice-growing areas of the Peninsula lag behind in the development of commercial crops and that the people are more completely subsistence farmers than even elsewhere in India is in a measure no doubt due to historical causes, but fundamentally the explanation lies in the specialized nature of traditional cultivation and the attitude it tends to engender. Provided that water in quantity and reasonably assured is available for the main rice crop of the year, the great majority are satisfied.

That the well is the chief source of irrigation within the trap formation is not due to any peculiar natural advantages. Irrigation, not being deemed urgently necessary for ordinary staples, is here only resorted to by those who have more than average initiative and means to employ it. It reaches its fullest expression nearest to the great consuming centers and where the railway has quickened contact with a world beyond the village horizon. It has virtually no place on the *regur* alluvial bottoms.

Desirability of Increasing Number of Wells

So far as can be ascertained the area under wells in India shows no tendency to increase. It is liable to fluctuate from year to year, as already observed, but the recorded returns for British India and certain native states indicate, over the last generation, outside limits

of about 11 and 14 million acres respectively. There is evidence to suggest that the extension of canal irrigation has unfortunately led to the abandonment of wells in some cases, and possibly the continually rising prices of draft animals and labor have operated in the same direction, but it is difficult to say how far they have been offset by a rise in the price of the products of intensive cultivation under wells.

The desirability of increasing the number and efficiency of wells in India is apparent. Such development demands, fundamentally, deeper wells; the modern bored well must displace the hand-dug well. This implies in loose material the tube well but in solid rock simply a drilled hole. In an existing well the boring is put down in the floor.[9] It is estimated that at present less than one per cent of the rainfall that penetrates underground in India is recovered. It is true that at best this proportion can never be a large one in any area, but nevertheless the additional supplies that would be yielded by bores of moderate depth would mean a considerable addition to the existing quantity and one that would be less readily affected by the vagaries of the seasons. Illustrations of this are not wanting; the following is chosen because it suggests that in coastal districts boring may help to solve the brine problem also. In Guntur, on the east coast, a boring 67 feet deep in a well 18 feet deep caused a rise of 9 feet of water and yielded a sweet supply in place of a brackish one.

Up to the present few bores have been sunk in the core of the Peninsula, and results have been poor compared with those obtained in the alluvium; but much more must be done before any statement of value concerning the deep-seated water supplies of the interior can be made. While in general the cost of boring compares favorably with that of an ordinary permanent well this is not the whole problem. Boring alone can achieve much in augmenting supplies of existing wells, but the effective utilization of deep wells is dependent upon the facility with which large quantities of water can be raised. The limitations of the existing age-old water lifts dependent either upon man power or bullock power are well known. As a result of experiments conducted over a number of years and associated particularly with the late Director of Industries, Madras, Mr. (now Sir) A. Chatterton, a variety of pumping plants, comprising oil engines and centrifugal pumps, have been produced. These are simple in design, straightforward to manipulate and maintain, indisputably both better and cheaper than the native devices on the existing larger wells, and capable of serving the modern deep wells that are beginning to appear. Exactly at what point it becomes profitable to employ

[9] The boring sunk from the surface is to be preferred on sanitary grounds and constitutes the "complete" well. On the other hand, as such it demands (if it is not actually artesian) a pump, while a bore sunk in any open well does not necessarily interfere with the existing indigenous lift.

such gear is not an easy question to answer in a few words or to express in non-technical language. On the basis of experience in Madras Chatterton states that, in order to make it worth while to install an engine and pump, the yield of a well should not be less than 10,000 cubic feet a day for the greater part of the year. Expressed in terms of acreage it appears that, to justify the application of the smallest scientific lift, a holding should not be less than 10 to 15 acres; and the number of such holdings in one block in India is very small. This fact, together with the large initial outlay and the maintenance costs involved indicates that, unaided, only the well-to-do landowner can be expected to take such a step.

However, the cultivator is not entirely unaided. Low-rate interest loans are available from the Government in addition to advice and assistance ranging over the whole field of the economic and technical considerations involved both in boring and the installation of pumping plant. But only the first act rests with even a most parental government; in the absence of an interested squirarchy success depends upon the coöperative movement, which in turn rests upon the extension of education, a plant of slow growth in India. But the results of twenty odd years are none the less encouraging.

The "Spring Channel"

Among the undefined means of irrigation in Peninsular India, grouped in official returns under the head of "other sources" and covering for the most part petty variations of the tank and canal, there is one form of undertaking, identified with the sandy bottomed beds of rivers of good fall and seasonal volume in Mysore and Madras, that has a distinctiveness meriting brief comment. This is the "spring channel." It takes the form of a channel excavated in the bed of a river, when this is dry, and carried downstream, often for several miles, at a flatter gradient than that of the river and the country around. At its head, and for a varying distance below this, the channel is below the level of saturation in the sand of the river, and water flows into and along it. Towards its lower end the bed of the channel becomes high enough to be taken through the bank of the river and continued above ground level. In this way water under flow is secured. Considerable labor is involved in digging anew the part of the work in the bed of the river itself that is destroyed every year and in clearing silt at the head of the channel. The distribution of water is very ingenious. A flat log is fixed horizontally in the channel so that all the water flows over it uniformly, and below this the water is divided into the required number of proportionate parts by a series of lesser channels separated from one another by vertical partitions.

MORICHES INLET: A PROBLEM IN BEACH EVOLUTION

R. S. Patton

Director, U. S. Coast and Geodetic Survey

IN February of this year, during one of the severe storms that characterized the past winter, an inlet broke through the barrier beach that separates Moriches Bay, on the south coast of Long Island, from the ocean. The occurrence raises interesting engineering and economic questions relative to beach conservation, particularly in view of the present and potential value of the land in this vicinity. The section of beach east of Fire Island Inlet, the scene of this action, is an important potential part of New York City's playground. It is nearer the city than any other ocean beach not yet extensively developed. The economic and social factors in the situation increase the importance of the physiographic problem.

He would be a rash prophet indeed who attempted to predict definitely what the situation will be at any point of this sandy cordon twenty or thirty years in the future; but, drawing on past experience, one can outline the probabilities. The inlet may close almost as suddenly as it opened. That has happened to a considerable number of inlets cut by storm waters and has been the disappointing outcome of a number of attempts to open inlets by artificial means. If closing is to occur, however, it is to be expected promptly: if such an inlet remains open long enough to establish an equilibrium it tends to be permanent.

The Case of Long Beach

On the other hand the inlet may not close. Let us consider what happened under similar conditions at Long Beach, some miles to the westward. Events can best be understood by reference to the sketches in Figure 1.

In 1835 the easterly point of East Rockaway Inlet was situated a little to the west of longitude 73° 41′. By 1860 this point had grown to the westward a distance of about 2¾ miles, or at an average rate of about one-tenth of a mile a year. This westward growth continued, and it is stated locally that by 1872 more than another mile of beach had been added to the point; in fact it is asserted by some that by that time the growth had attained to a position a little west of longitude 73° 46′, and the point had attached itself to the mainland, closing the inlet.

In 1872 a new inlet broke through the beach at about longitude 73° 41′. Apparently the inlet required some years to establish its regimen, for in 1879 the westward growth of the new easterly point had scarcely begun. By 1909 this westward growth had added 2½ miles to the length of the beach, and between 1909 and 1927 another three-quarters of a mile was added.

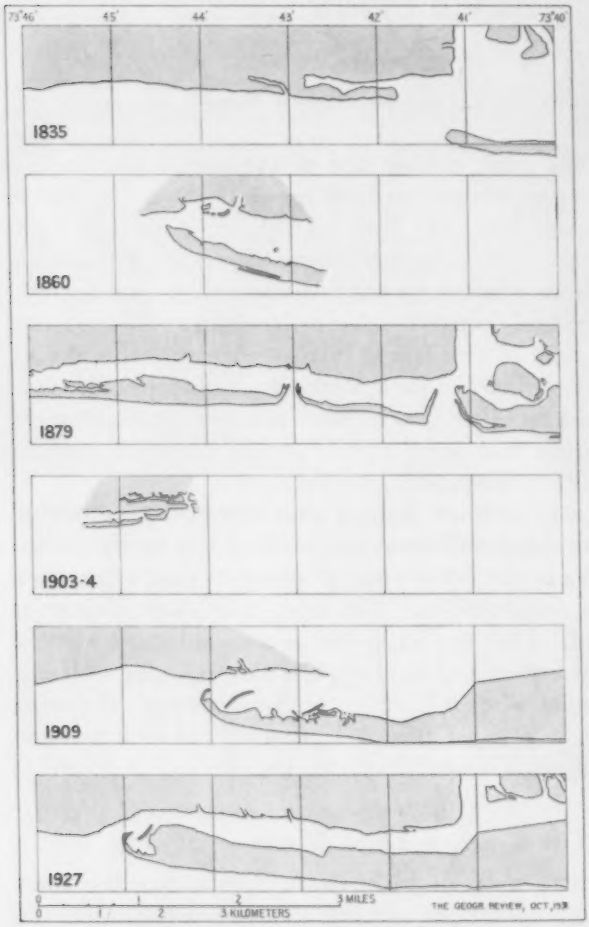

FIG. 1—Stages in the evolution of Long Beach, L. I.

When the new inlet opened, it became the principal passageway for the flow of tidal waters into and out of the interior basins. Thereupon the old inlet, some 4 miles or more to the westward, immediately closed, if in fact it had not already done so; and a long finger-like peninsula extended to the eastward from its connection with the mainland at its western extremity. This peninsula rapidly disintegrated. By 1879 it had broken into two parts. An island that constituted its eastern part had eroded to such an extent that sand dunes and vegetation had disappeared, and it consisted of little more than a low flat sand spit across which the waves broke in every storm, driving the sands to the northward, filling up the old East Rockaway channel, and, as it were, causing the island to migrate bodily toward the mainland.

Subsequent to 1879 the same process must have applied to the western half of the peninsula, for by 1903–1904 all that remained of the old beach was the low, narrow sand spit shown, which at that

time was about to lose its identity completely by merging into the main body of Long Island. By 1909 this merger had been completed, and the only vestige of the old beach that remained above low water could be traced in a slight southward extension of the south shore of the main island.

As the new point grew to the westward the inlet channel at all times was pushed ahead of it. Hydrographic surveys of this inlet were infrequent, but such as were made show depths as great as 34 feet and suggest a probable average depth of from 12 to 15 feet. Presumably all submerged traces of the earlier beach that wave action had not previously removed were scoured away by the inlet to the depths indicated.

Is this cycle of change unique, or is it typical, at least in a general way, of the changes that may be expected to occur generally with the opening of new inlets? Apparently we must accept the latter view. In the first place, a century of surveys of the coast reveals other places where similar cycles have occurred. In the second place, the available evidence suggests the probability that during earlier periods Long Beach itself went through cycles of change closely resembling the one here described. For example, one is justified in believing that the 1835 survey shows a stage of a similar preceding cycle intermediate between those shown by the 1879 and the 1903–1904 surveys, and the 1860 stage is quite similar to that of 1909. Finally, a study of the forces by which these changes are produced compels the conclusion that if some abnormal combination of circumstances starts a section of the beach upon a new cycle, one must expect that cycle quite faithfully to duplicate similar ones that have preceded it in the same general locality.

Winds and Waves in Beach Evolution

In seeking to establish the relationship between cause and effect in beach evolution, one is at once impressed by the direct and obvious connection between shore changes and the weather. Other factors enter in: for example, in the vicinity of the inlets the tidal currents become of great importance. In general, however, in the writer's opinion, the wind, through the medium of the waves it produces and of certain other concurrent effects upon the water, is the most important agency involved in the production of shore-line changes. The writer has studied the problem intensively at various sections of the coast. His conclusions may be summarized approximately as follows:

Each wind, with its accompanying waves, has its own characteristic effect upon the beach.

The ground swell, the product of distant winds, has variable

effects. It tends to approach the shore in a direction at right angles to the beach and frequently to cause a landward migration of unconsolidated material recently deposited in the shoal-water zone bordering the coast, with a consequent accretion to the beaches. However, with an increase in size the ground swell may produce effects similar to those next to be described.

A storm wind blowing from seaward at right angles to the beach produces waves that come in broadside to the shore. It backs the water up against the shore, frequently elevating the water surface there as much as 2 or 3 feet above its normal level. The resulting increased depth permits larger waves to reach the beach unbroken and expend their energy in a concentrated attack on the bare sands. The usual result is erosion. However, the sands are carried directly seaward by the returning backwash, probably aided by a seaward-flowing bottom current resulting from the piling up of the water against the beach; and, while some part of the sand probably is carried away beyond the possibility of recovery, a larger part is usually deposited a short distance out from shore, in a position from which it can later be restored to the beach if the proper weather conditions ensue.

When wave approach is oblique to the shore, erosion attains its maximum. The waves cut into the beach like scythes mowing down a field of grain. In a few hours they can cut away a triangular section, reducing the normal beach slope to the horizontal and leaving a vertical cliff in the sand to mark the limit of their penetration.

These oblique waves also produce a current which can be plainly seen flowing to leeward close to shore, like some turbid river, laden to capacity with sands eroded from the beach. The tendency of this current is to remove the eroded materials to such great distances, either out to sea or into the inlets, that their subsequent restoration to the beach becomes more difficult.

A strong wind blowing off the land tends to produce accretions, particularly if it occurs shortly after a period of erosion. Such a wind tends to increase the heights of the incoming waves and steepen their fronts. These alterations in the wave form are accompanied by corresponding changes in the motion of the water particles of which the wave is composed. The forward motion becomes a briefer impulse at higher velocity, producing a short, powerful thrust which is very effective in moving material landward. The wind also blows the surface water seaward, sometimes lowering the level from 2 to 3 feet below its normal position. This results in a bottom landward-flowing current which under favorable conditions will combine with the wave motion to restore large quantities of sand to the shore. It is axiomatic along portions of the mid-Atlantic coast that "a west wind builds up the beach."

Local Factors on the Southern Shore of Long Island

These general characteristics are subject to modification by local factors, and one such factor dominates the situation on the south shore of Long Island. The south shore of Long Island trends mainly east and west; the shore of the northern part of New Jersey roughly north and south. Together, the two shores form the funnel-like approach to New York. Each shore, to a gradually diminishing extent eastward and southward respectively, tends to limit the arc throughout which a vigorous wave attack can be delivered against the other. Such attack therefore comes predominantly from the southeast. In consequence, there is an abnormal tendency toward a westward migration of inlets and growth of spits on the Long Island shore, and a similar northward movement on the New Jersey shore. Probably this movement is accelerated by alongshore components of the flood tide. Sandy Hook, Coney Island, Rockaway Beach, Long Beach, and Fire Island Beach are outstanding examples of this tendency.

With respect to any unit volume of sand the migration must be variable and intermittent. Even if only the part of the sand that is in transit in the alongshore current be considered, it is scarcely conceivable that the total volume delivered to that current by each wave stroke is carried intact for any great distance. The process seems to be one of constantly picking up material and carrying it to leeward and also of constantly depositing other material derived from points to windward.

There is, however, one important limitation upon this rule. At the windward extremity of any unit of beach the attack in any storm is delivered by waters that have had little or no previous opportunity to accumulate a load of sediment. Consequently they have a maximum capacity to remove material and a minimum tendency to deposit it, and the net result tends to be a permanent loss of beach.

The presence of a continuous land barrier on one side is essential to the existence of the alongshore current. When the current reaches an inlet it tends to be dissipated. Its burden is either deposited at the point of dissipation or seized upon by the inlet currents and carried either into the basin or seaward, where deposition quickly occurs. In this manner shoals are formed in the basin, particularly a shoal just inside the inner end of the inlet gorge. A fanlike shoal grows ahead of the point, and material brought by wave action from this shoal to the point tends to cause the latter to advance.

In the case of an old inlet of well established regimen the sands in transit seem able to find their way past the inlet to the next adjacent section of beach. The process as it probably works out is too complicated for brief description, but it can be said that at such an inlet

the alongshore drift is not seriously and permanently interrupted and that, if in the long run the permanent losses from one inlet point exceed those from the other, the causes probably will be found to be local rather than general.

Not so, however, with the newly opened inlet. The opening consists of a ragged, amorphic gash cut squarely across the beach. Nature's first concern is to bring order out of this chaos, to rearrange materials into the systematic, orderly pattern of channels and shoals in which each existing force is brought into a delicately adjusted balance with all the others. The process takes years and, particularly during its early stages, seems to use up all the sand that can be brought to the inlet by the alongshore drift. The first crude and obvious manifestation of the process is the appearance and growth of an extensive shoal inside the inner end of the inlet gorge. Into the building of that shoal go the sands that formerly continued along the beach to help make good the toll taken by the waves from the adjacent leeward section, with the result that large, permanent losses of beach are prone to occur in that locality during the period shortly following the opening of a new inlet. Long Beach is only one of a number of similar examples.

There is no ground for expecting Moriches Inlet to prove an exception to the rule. If the inlet does not reclose and if man does not intervene during the next few years an accelerated erosion of the beach for some distance west of the opening can reasonably be expected and in due time the beginning of a westward migration of the inlet.

THE CLIMATES OF NORTH AMERICA
ACCORDING TO A NEW CLASSIFICATION

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[With separate map, Pl. III, facing p. 654]

DURING the last decade a number of the sciences closely related to geography, in particular plant ecology, soil science, and geomorphology, have experienced remarkable development. The climatic basis of the distribution of plants, of soils, and of land forms has received considerable attention and has been reduced to a certain degree of order. It has been recognized by the scientists working in these fields that their development on a truly scientific basis is dependent on the consideration of climate in quantitative terms. As yet, however, their studies have dealt only with certain elements of climate of certain regions. The one classification of world climates developed on a quantitative basis which has been widely accepted has been devised by Köppen.[1]

Köppen attempted to determine the limits of the arid climates on the basis of drainage patterns peculiar to arid regions, and he ascertained the combinations of mean annual temperature and precipitation that occur along their borders. His findings were reduced to a formula that expresses the mean annual depth of precipitation (in centimeters) at various mean annual temperatures (expressed in degrees Centigrade) along the moister limits of the dry climates.[2]

The dry climates are designated steppe or desert depending on whether they receive more or less than half the critical amount of precipitation. Köppen recognized that where there are distinct wet and dry seasons in summer or winter the period of occurrence is important, for summer rainfall is less effective than winter rainfall since evaporation is higher in summer than in winter. He allowed for variations in evaporation by increasing the precipitation factor of a given climatic division in the summer-rainy area and reducing it in the winter-rainy area.

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[1] Wladimir Köppen: Versuch einer Klassifikation der Klimate, vorzugsweise nach ihren Beziehungen zur Pflanzenwelt, *Geogr. Zeitschr.*, Vol. 6, 1900, pp. 593–611, and 657–679; *idem:* Klassifikation der Klimate nach Temperatur, Niederschlag und Jahreslauf, *Petermanns Mitt.*, Vol. 64, 1918, pp. 193–203 and 243–248; *idem:* Die Klimate der Erde, Berlin und Leipzig, 1923. A newer classification appears in Köppen-Geiger, Klimakarte der Erde (1:20,000,000), Justus Perthes, Gotha, 1928.

[2] Leighly has converted these formulae into English equivalents. See J. B. Leighly: Graphic Studies in Climatology, *Univ. of California Publs. in Geogr.*, Vol. 2, 1926, No. 3, pp. 55–71; reference on p. 62.

Köppen's system has been utilized in local analyses by certain American students. Van Royen[3] applied it to eastern North America and Russell[4] to California and later to the arid regions of the United States. An attempt to adapt elements of Köppen's classification to ecological use was made by Eric McDougall[5] in "The Moisture Belts of North America." Russell discovered that the general classification did not adequately express the climatic diversity of California nor of the arid climates and so introduced a number of modifications. Van Royen followed Köppen's classification without modifications, but he also appreciated the fact that it did not give a satisfactory view of the differentiation of the climate of North America.

In considering Köppen's formula in relation to evaporation Matthews[6] finds that it includes a "term which is theoretically unsound," and suggests that, although the classification is of value in Chile in spite of a "false assumption," his formulae "should be critically examined elsewhere in respect of their validity."

The great scientific value of Köppen's classification lies in the fact for which he is most criticized, that, "in the designation of climatic types he deliberately makes exclusive use of numerical climatic values.[7] Leighly has pointed out that whoever applies the classification to any part of the earth will arrive at the same result as another who works with the same observational data. Although this basic principle will not be superseded, the formulae adopted by Köppen and his actual classification have been demonstrated to lack validity in a number of respects.

Evaluation of Temperature and Precipitation

It is understood that degree of temperature and amount of precipitation and seasonal variations of each are the most important climatic elements, but it has been recognized that the crude measurements of these elements are not satisfactory. Two methods of dealing with temperature have been employed. In one case limiting values of temperature have been determined; and, in the other, means of determining the efficiency of temperature have been obtained. The temperature boundaries of Köppen's regions are mean temperatures of the coldest or warmest months or groups of months. Livingston

[3] W. Van Royen: The Climatic Regions of North America, *Monthly Weather Rev.*, Vol. 55, 1927, p. 315.

[4] R. J. Russell: Climates of California, *Univ. of California Publs. in Geogr.*, Vol. 2, 1926, No. 4, pp. 73–84; *idem:* The Dry Climates of the United States, *ibid.*, Vol. 5, 1931, No. 1, pp. 1–41.

[5] Eric McDougall: The Moisture Belts of North America, *Ecology*, Vol. 6, 1925, pp. 325–332. See the maps in *Geogr. Rev.*, Vol. 17, 1927, p. 323.

[6] H. A. Matthews: Köppen's Climatic Formulae and Chilean Evaporation Data, *Scottish Geogr. Mag.*, Vol. 47, 1931, pp. 159–163.

[7] E. Obst: Die Klimate und ihre geographische Verbreitung, Enzyklopädie der Erdkunde Lufthulle und Klima, Leipzig and Vienna, 1923, p. 163.

states[8] that "what appears to be requisite in this general connection is some kind of temperature indices which shall express the temperature values not in ordinary thermometric terms but in terms of the possible *effectiveness* of the observed temperatures in determining the rate of plant growth." He has described three forms of temperature efficiency indices: (1) "remainder indices" where some constant is subtracted from the temperature and the result supposed to indicate the relative growth rate of plants for the period; (2) "exponential indices" where some function of temperature is an exponent of a constant and the result considered to indicate the relative growth rate of plants; and (3) "physiological indices" where the growth rates of particular plant species at various temperatures are experimentally determined and are used as temperature efficiency indices.

The problem of determining the effectiveness of precipitation is rendered complex by the fact that the amount of moisture available for plant growth depends not only upon the amount of rainfall but also upon the loss by evaporation of which, to the present, very few records have been obtained. A quarter of a century ago Transeau[9] attempted to obtain an index of precipitation effectiveness by using the quotient of total annual measured precipitation and annual evaporation as computed for a period of twelve months in 1887 and 1888 for about 150 stations by Russell.[10] In 1915 Lang[11] utilized in his study of soil distribution what he called a rain factor, which is the quotient of annual precipitation in millimeters divided by mean annual temperature in degrees Centigrade. This computation is based on the premise that evaporation varies directly with and in the same amount as mean annual temperature, which of course is not the case. In 1926 Hirth[12] published a map dividing the world into moisture provinces, which he computed by using Lang's rain factor. De Martonne's[13] "index of aridity" is a slight modification of Lang's rain factor. Whereas Lang's formula is P/T, De Martonne's

[8] B. E. and G. J. Livingston: Temperature Coefficients in Plant Geography and Climatology, *Botan. Gazette*, Vol. 56, 1913, pp. 349–375.

B. E. Livingston: Physiological Temperature Indices for the Study of Plant Growth in Relation to Climatic Conditions, *Physiol. Res.*, Vol. 1, 1916, pp. 399–420.

[9] E. N. Transeau: Forest Centers of Eastern America, *Amer. Naturalist*, Vol. 39, 1905, pp. 875–889.

[10] Thomas Russell: Depth of Evaporation in the United States, *Monthly Weather Rev.*, Vol. 16, 1888, pp. 235–239.

[11] Richard Lang: Verwitterung und Bodenbildung als Einführung in die Bodenkunde, Stuttgart, 1920, pp. 107–123.

[12] Paul Hirth: Die Isonotiden, *Petermanns Mitt.*, Vol. 72, 1926, pp. 145–149: reviewed in *Geogr. Rev.*, Vol. 17, 1927, pp. 335–338.

[13] Emmanuel de Martonne: Aréisme et indice d'aridité, *Comptes Rendus de l'Acad. des Sci. [de Paris]*, Vol. 182, 1926, June 7, pp. 1395–1398; *idem:* Regions of Interior-Basin Drainage, *Geogr. Rev.*, Vol. 17, 1927, pp. 397–414. Recently L. Emberger has devised an "expression synthétique du climat," described in his paper "La vegetation de la région méditerranéenne" in *Rev. Gén. de Botanique*, Nov., 1930. It produces an index of aridity more satisfactory than de Martonne's in its application to Mediterranean climates. See also *Comptes Rendus de l'Acad. des Sci. [de Paris]*, Aug. 25, 1930, pp. 389–391.

is P/T–10. In both cases precipitation in millimeters and temperature in the Centigrade scale are used. Meyer's[14] N–S quotient (Niederschlag-Sattigungsdefizit) was obtained by dividing the precipitation by the saturation deficit.[15] To evaluate the effectiveness of precipitation Szymkiewicz[16] obtained what he termed "le quotient hygrométrique," which is the measured amount of precipitation divided by the index of evaporation. Since the index of evaporation is determined by the use of an equation that includes atmospheric pressure and vapor tension of the air as well as temperature, this hygrometric quotient can be obtained only for stations where complete meteorological records are available.

With measurements of evaporation so rare and incomplete, representation on a map of the effectiveness of precipitation in terms of evaporation will be highly schematic and indefinite. Obviously an approximate computation of the precipitation-evaporation quotient in a great many stations would give more accurate and more satisfactory results than the use of only the few stations where evaporation measurements have actually been made. In the present study a method has been devised whereby the precipitation-evaporation quotient can be computed where only the mean monthly temperature and monthly precipitation are given. Although other climatic factors influencing evaporation, such as vapor tension, wind, and atmospheric pressure, have not been taken into consideration, the resulting error makes no significant difference in the results.

Precipitation Effectiveness

Evaporation measurements made at twenty-one stations in the western United States for the months of April to September inclusive for periods ranging from four to twelve years were published in the *Monthly Weather Review* of October, 1921.[17] For each of these evaporation measurements the corresponding monthly precipitation and mean monthly temperature were obtained from *Bulletin W*.[18] The three sets of climatic data were appropriately grouped, and the quotient of precipitation divided by evaporation was determined. This quotient P/E is called the P–E (precipitation-evaporation)

[14] Alfred Meyer: Über einige Zusammenhänge zwischen Klima und Boden in Europa, *Chemie der Erde*, Vol. 2, 1926, pp. 209–347.

[15] Compare the discussion of Lang's and Meyer's factors by E. Blanck in "Die Verwitterung in ihrer Abhängigkeit von den äusserer klimatischen Faktoren," Handbuch der Bodenlehre, Vol. 3. Berlin, 1930, pp. 10–11.

[16] Dezydery Szymkiewicz: Études climatologiques, *Acta Societatis Botanicorum Poloniae*, Vol. 2, 1925, No. 4.

[17] R. E. Horton: Results of Evaporation Observations, *Monthly Weather Rev.*, Vol. 49, 1921, pp. 553–566. See also C. E. Linney: Ten Years of Evaporation in the Southwest, *ibid.*, Vol. 55, 1927, pp. 320–322.

[18] *U. S. Weather Bur. Bull. W*, 2nd edit., 1926.

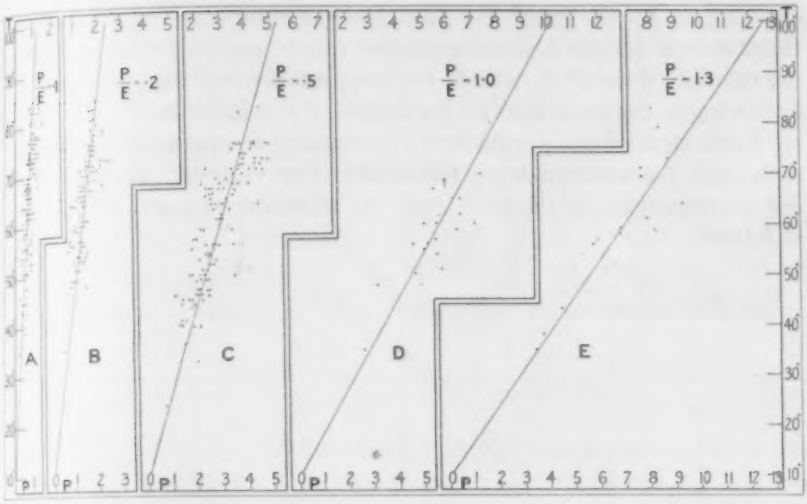

FIG. 1

ratio. The total annual precipitation divided by the total evaporation is called the *P–E* quotient. The sum of the twelve monthly *P–E* ratios is called the *P–E* index. It should be noticed that the *P–E* index is different from the *P–E* quotient.

The data for 1914 at Woodward, Okla., illustrate the procedure:

	APRIL	MAY	JUNE	JULY	AUG.	SEPT.
Temp. (°F.)	58.0	66.0	81.0	83.0	79.0	75.0
Precip. (in.)	2.44	3.53	0.60	0.92	2.92	0.82
Evap. (in.)	6.83	6.23	11.27	11.00	8.94	8.35
P/E	.33	.5	.05	.1	.33	.1

In all more than 1100 groups of figures were available, and *P–E* ratios were obtained for each. The groups were then rearranged so that all having similar *P–E* ratios were together, the dates and locations in this case being ignored. For instance, the *P–E* ratios for July and September above are the same, 0.1 in both cases. They were combined into a single table with all other groups from the other stations where the *P–E* ratio is 0.1. In the same way the data associated with all other *P–E* ratios were tabulated. These data were then represented graphically, a separate graph being made for each *P–E* ratio. The mean monthly temperature was plotted along the ordinate, and the monthly precipitation along the abscissa. A study of the plots revealed the fact that in every case a straight line cutting the

ordinate at 10° F. fitted the data satisfactorily (see Fig. 1). From these several graphs a single equation was formulated that expressed the relation of the P–E ratio to the temperature and the precipitation. Following is the basis for the derivation of the formula.

From each of the graphs two functions of temperature, precipitation, and evaporation were obtained. For various values of P/E the corresponding values of P/T–10 were determined. They are as follows:

$x = P/E$		$y = P/T$–10	
x	y	x	y
.0	.0	1.3	.1416
.1	.0139	1.5	.1608
.2	.0262	2.0	.2080
.3	.0385	2.5	.2515
.4	.0484	3.0	.296
.5	.0597	4.0	.383
1.0	.1111	...	.....

These functions when plotted on logarithmic paper demonstrated that the equation would be in the form:

$$y = kx^n$$

Thus $\log y = \log k + n \cdot \log x$

Let $u = \log x$

$v = \log y$

$w = \log k$

Then $v = w + nu$.

For convenience the two functions P/E equals 0.2 and P/E equals 2.0 were taken.

x	u $\log x$	y	v $\log y$
.2	−.69897	.0262	−1.58170
2.0	.30103	.208	− .68194

using first figures $-1.58170 = w - .69897n$

using second figures $-.68194 = w + .30103n$

subtracting $-..89976 = -n$

$n = .89976$ or approximately .9

substituting in first equation $w = .69897n - 1.5817$

$w = -.953$

$\log k = -.953$ or $9.047 - 10$

$k = .1114$

substituting in original equation

$$y = .1114\,x^{.9}$$

$$\frac{P}{T-10} = .1114\left(\frac{P}{E}\right)^{.9}$$

$$\left(\frac{P}{E}\right)^{.9} = \frac{P}{.1114\,(T-10)}$$

$$\frac{P}{E} = \left(\frac{P}{.1114\,(T-10)}\right)^{\frac{10}{9}}$$

$$\frac{P}{E} = \left(\frac{1}{.1114}\right)^{\frac{10}{9}} \cdot \left(\frac{P}{T-10}\right)^{\frac{10}{9}}$$

final equation

$$\frac{P}{E} = 11.5\left(\frac{P}{T-10}\right)^{\frac{10}{9}}.$$

As seen in Figure 1 the data used in the development of the formula are most abundant in the temperature range between 40° F. and 80° F. and do not extend below 30° F. nor above 90° F. There is no experimental or statistical justification for extending the lines below 30° F., and a theoretical consideration of the data demonstrates that the lines should not intersect the y axis at 10° F. or at any other place. The physical interpretation of the curves (Fig. 1) is that there is no precipitation at or below 10° F., which of course is not true. It is true, however, that where P/E is constant P varies directly as T, and as T becomes very low, P becomes extremely small and approaches zero. Consequently, since the curve P/E should be asymtotic to the y axis, a better fit for the data plotted in Figure 1 than is possible with straight lines converging at 10° F. would be obtained by hyperbolas asymtotic to the y axis and also to these straight lines. This can be made clear by means of an illustration. The equation of the straight line passing through the field of points where P/E equals 0.2 is

$$T = 38.2\,P\,10$$

The equation of a hyperbola with the properties described above is

$$T = 38.2\,P\,10 - \tfrac{33}{P}$$

The greater the value of P the smaller will be the value of the fraction $\frac{33}{P}$ and the closer will the hyperbola approach the straight line. As P becomes very small, the $\frac{33}{P}$ becomes very large. The value of this fraction is subtracted from a variable which is approaching 10 as a limit. Thus as P approaches zero, T approaches negative infinity.

Precipitation that occurs at temperatures below 32° F. is in the solid state and performs no ordinary work of erosion or soil modification or is not available for plants until it melts. Thus precipitation that occurs at these low temperatures has the same effectiveness as though it fell at approximately 32° F. because it is only at that temperature that it becomes available. Through empirical means it

was determined that the minimum effective mean monthly temperature is 28.4° F. (−2° C.) rather than 32° F. Thus it may be seen that the formula, although it fails at temperatures lower than 20° F., may be used safely to that temperature and is actually used only to 28.4° F. In the use of the formula temperatures below 28.4° F. are to be reckoned on the basis of the effectiveness at that temperature.

The quotient P/E is considered the precipitation effectiveness ratio of a single month. To obtain the precipitation effectiveness of the station the sum of the twelve monthly P–E ratios was obtained. This is called the P–E index. It is clear that this P–E index is not at all the same as the ratio of the sum of the monthly precipitation figures to the sum of the monthly evaporation figures (P–E quotient) which was the one Transeau used in 1905. Since the P–E index is not in the same units as precipitation or evaporation nor even in percentages, to avoid the inconvenience of dealing with fractions each quotient has been multiplied by ten. Thus the precipitation effectiveness index (P–E index) is ten times the sum of the twelve monthly P–E ratios.

$$I = P\text{–}E \text{ index}$$

$$I = \sum_{n=1}^{12} 10\left[\frac{P}{E}\right]_n \quad \text{or}$$

$$I = \sum_{n=1}^{12} 115 \cdot \left[\frac{P}{T-10}\right]_n^{\frac{10}{9}}$$

The formula, derived from actual observational data, describes the relation which here exists between the P–E ratio and precipitation and temperature. In other words the formula gives the P–E ratio in terms of precipitation and temperature. Thus for every station where monthly observations of precipitation and temperature have been made it is possible to compute the P–E ratio and the P–E index, which becomes an evaluation of the effectiveness of the precipitation. The computation of the P–E index by means of the formula is a laborious process; and, since the data were subject to plotting, a nomogram was constructed which permitted its graphical determination (see Figs. 12 and 13). In the use of the graph as well as the formula temperatures below 28.4° F. are reckoned on the basis of the effectiveness at 28.4° F.

A second arbitrary modification was introduced into the use of the formula and the chart. P–E ratios greater than 40 were counted as 40 since it was found that P–E ratios that are considerably less than this represented rain-forest conditions.

The method outlined was first applied to the United States. The

P–E index was determined for every station whose temperature and precipitation records extended through a period of ten years or more. Nearly 3000 of these indices were plotted on a map, and the *P–E* index isopleths were drawn. Through actual field observation and study of vegetation maps and monographs five major humidity provinces were recognized and defined (Fig. 2). They are as follows:

Humidity Province	Characteristic Vegetation	*P–E* Index
A (Wet)	Rain forest	128 and above
B (Humid)	Forest	64 to 127
C (Sub-humid)	Grassland	32 to 63
D (Semiarid)	Steppe	16 to 31
E (Arid)	Desert	less than 16

The final check on the validity of the method and the value of the *P–E* indices would be to compare the indices with the growth of plants. Weaver[19] collected a series of data on the dry weight increment of native vegetation in cut quadrats at three stations in the grasslands of the central United States. These stations were similar in temperature efficiency but differed considerably in precipitation effectiveness. The *P–E* index was compared with Weaver's plant growth index (weight of vegetation in unit area) with the following results:

Station	*P–E* Index	Plant Growth Index 1921	Correlation Coefficient	Plant Growth Index 1922	Correlation Coefficient
Burlington, Colo. . .	30.0	353	11.8	224	7.5
Phillipsburg, Kan. . .	38.0	402	10.6	316	8.3
Lincoln, Neb.	51.4	603	11.8	442	8.5

The correlation coefficient is the quotient of plant growth index divided by *P–E* index. In the 1921 figures the correlation between Burlington and Lincoln is perfect. The plant growth index of Phillipsburg is somewhat lower than might be expected. In those for 1922 the plant production for Burlington is slightly less than is to be expected on the basis of the *P–E* index, 224 instead of 258. These figures are not sufficient to draw any conclusions concerning the *P–E* indices; but they illustrate a method of research well worth pursuing.

Seasonal Distribution of Precipitation Effectiveness

Because of the roughly cyclic character of the annual march of temperature and precipitation and the consequent seasonal variations

[19] J. E. Weaver: Plant Production As a Measure of Environment, *Journ. of Ecology*, Vol. 12, 1924, pp. 205–237.

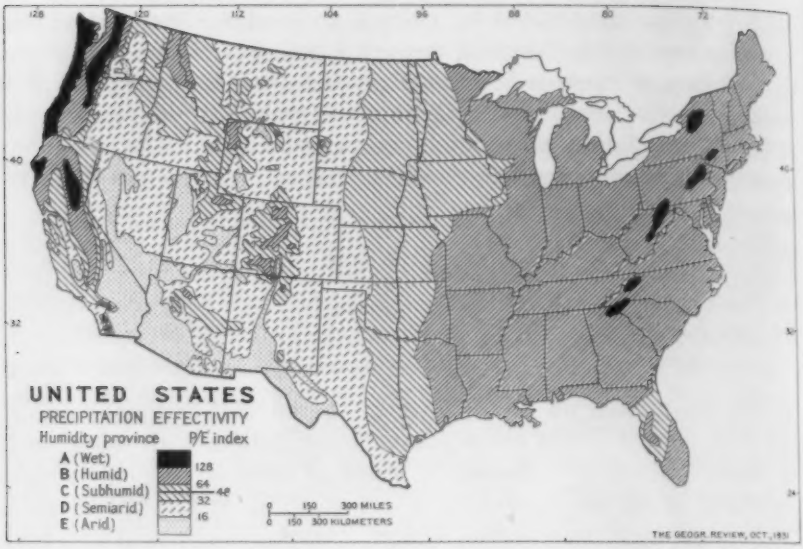

FIG. 2

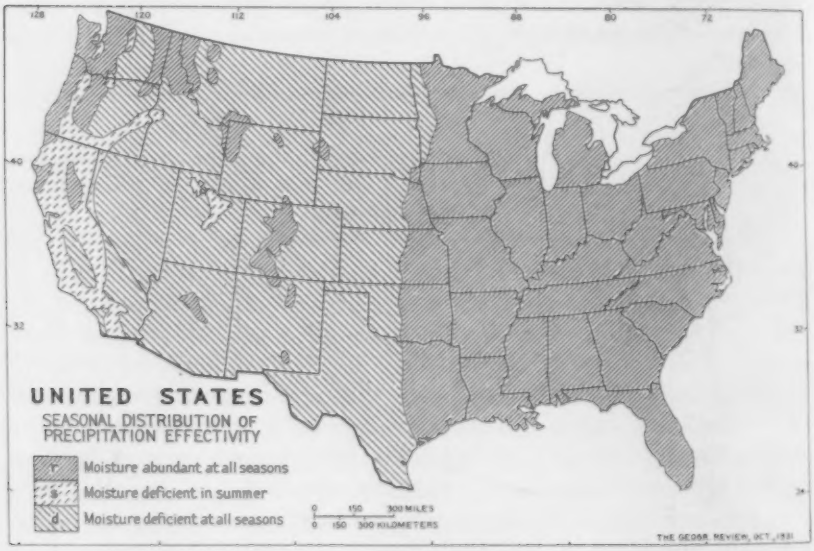

FIG. 3

in the *P–E* ratio it has been necessary to distinguish between the seasonally dry and the continuously rainy or continuously dry areas. Four subtypes have been recognized.

r.....moisture abundant at all seasons
s.....moisture deficient in summer
w.....moisture deficient in winter
d.....moisture deficient at all seasons

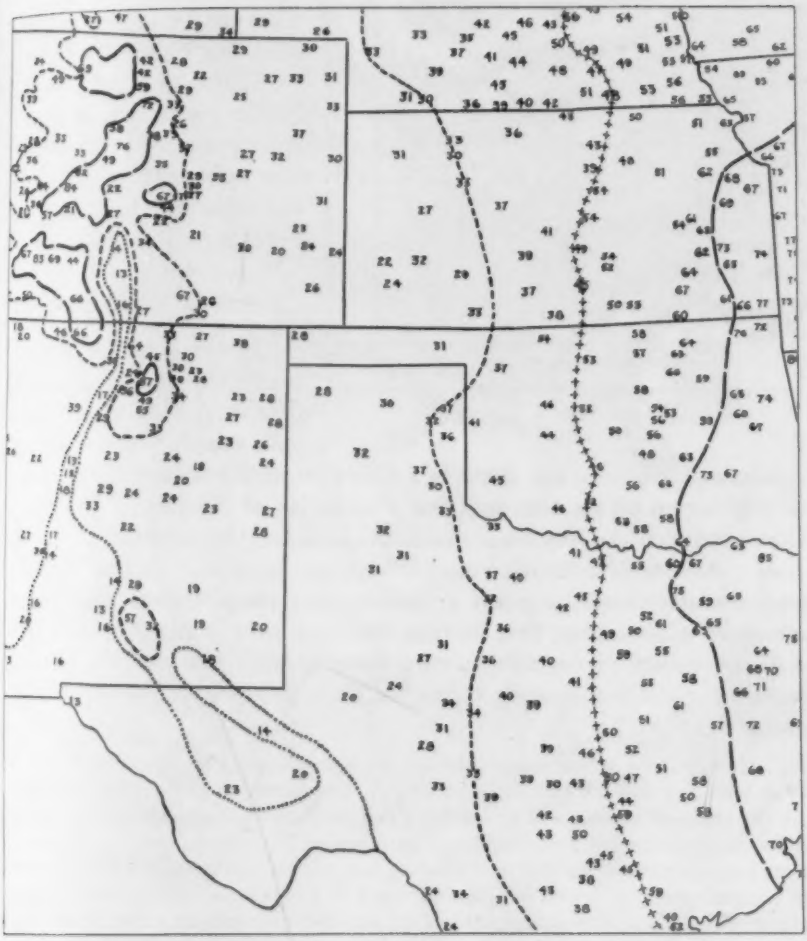

FIG. 4—Portion of the map on which Figure 2, Precipitation Effectivity, is based, showing the plotting of data. The line of crosses is P/E index 48, approximately dividing humid east from arid and semiarid west.

A chart for determining these four subtypes has been devised (Fig. 5). Here the abscissa is the *P–E* index and the ordinate is the sum of the three *P–E* ratios of summer or winter depending on which is greater.

To be classed as **r** the *P–E* index must be more than 48 and the highest index of seasonal effectiveness less than half the total unless the total exceeds 128. When the winter effectiveness index is more than 16 and more than half the *P–E* index, which must be less than 128, the subtype is **s**. If the summer effectiveness index is more than 16 and more than half the *P–E* index, which is less than 128, the subtype is **w**. In **d** the *P–E* index is less than 48, and the highest index of seasonal effectiveness is less than 16 or less than half the total.

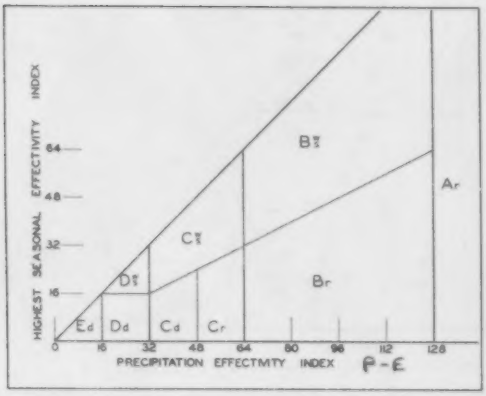

FIG. 5

This can be understood by studying Figure 5.

While all are developed in the continent of North America only three of the four subtypes are found in the United States (see Fig. 3).

TEMPERATURE EFFICIENCY

In the consideration of precipitation effectiveness it is seen that where thermal, edaphic, and cultural conditions are constant there is a direct relation between the amount of vegetation on an area and the *P–E* index of the area. The lower the *P–E* index the less favorable is the area for the growth of vegetation. Aridity is a limiting factor for plant growth. It has likewise been demonstrated by plant ecologists and physiologists that when moisture is adequate, to a certain limit the rate of plant growth and the abundance of vegetation vary directly with temperature.[20] Insufficient heat is a limiting factor for plant growth just as is deficient moisture.

> "Temperature is like water in its action upon plants in that it has more or less to do with nearly every function, but as a working condition and not as a material. All the chemical processes of metabolism and also many physical processes such as diffusion, precipitation, and coagulation as in cell-wall formation, etc., are dependent upon temperature and accelerated by its increase up to an optimum. With a decrease in temperature to a certain minimum, growth in size is retarded; at lower temperatures, cell division and photosynthesis are also checked; and, at a still lower minimum, respiration ceases and death ensues. Thus, temperature is not only necessary for life processes but also furnishes the energy for some of them."[21]

Just as temperature as a working condition affects plant metabolism and growth the same as precipitation does as a material, so high temperature and abundant precipitation are alike in stimulating chemical activity in soil formation and in the development of drainage and surface features of the landscape. Temperature efficiency then is a phenomenon equivalent in many respects to precipitation effectiveness. In developing a rational classification of climate it seems desirable to attempt to express the limiting effect of low temperatures and the stimulating effect of high ones with the same coefficients

[20] B. E. and G. J. Livingston, *op cit.*
P. A. Lehenbauer: Growth of Maize Seedlings in Relation to Temperature, *Physiol. Res.*, Vol. 1, 1914, pp. 247–288.
B. E. Livingston, *op. cit.*, Vol. 1, 1916, pp. 399–420.

[21] J. E. Weaver and F. E. Clements: Plant Ecology, New York, 1929, p. 275.

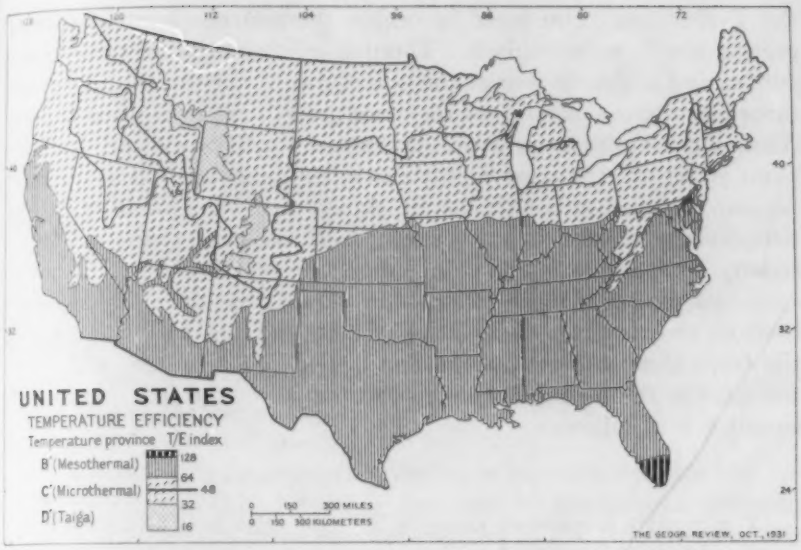

FIG. 6

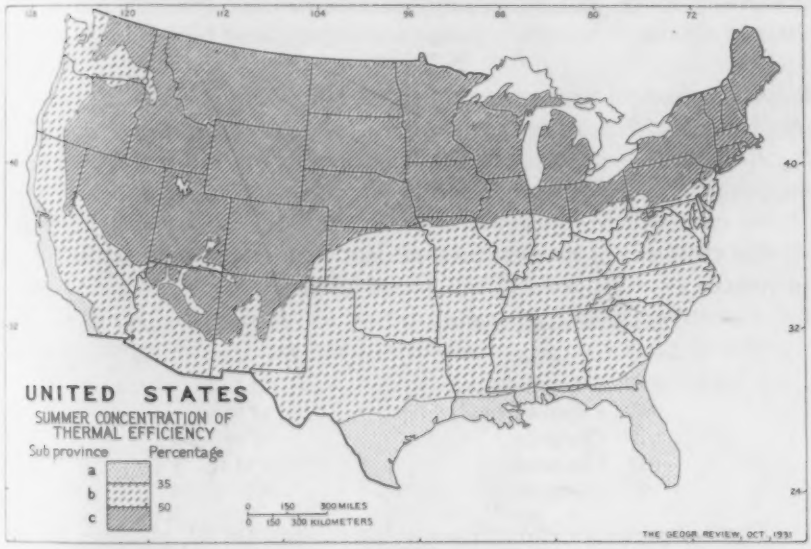

FIG. 7

as the limiting and stimulating effects of deficient and abundant precipitation have already been expressed.

Precipitation effectiveness has been expressed as an accumulated sum of the effectiveness ratios of individual months; an equivalent coefficient for temperature efficiency would require a similar method of expression. The monthly coefficient of thermal efficiency is called the T–E ratio. The sum of the twelve monthly ratios is called

the T–E index. The least favorable thermal conditions for plant growth are in polar regions. Thermal efficiency is very low in the tundra and is clearly zero at the polar limit of the tundra. The most favorable thermal conditions for plant growth are in tropical regions. Assuming that the most favorable thermal conditions would stimulate plant growth to the same extent and in the same amount as the most favorable moisture conditions, it should not be difficult to derive temperature efficiency coefficients, T–E indices, which would be strictly comparable to the P–E indices already presented. Through empirical means an equation was developed that gave the poleward limit of the tundra a T–E index of zero and the poleward limit of the tropical rain forest and savana a T–E index of 128, which was the same as the P–E index of the arid margin of the rain forest. The equation is as follows:

$$i' = \frac{T-32}{4}$$

T = monthly temperature values in °F.[22] (the value 32 is used for temperatures below 32° F.).
i' = monthly index of temperature efficiency (T–E ratio)
I' = T–E (temperature efficiency) index (summation of monthly indices)

$$I' = \sum_{n=1}^{12} i'n \qquad \text{or,}$$

$$I' = \sum_{n=1}^{12} \left(\frac{T-32}{4}\right)_n .$$

On the basis of temperature efficiency summation six temperature provinces were defined. They are as follows:

Temperature Province	T–E Index
A′ (Tropical)	128 and above
B′ (Mesothermal)	64 to 127
C′ (Microthermal)	32 to 63
D′ (Taiga)	16 to 31
E′ (Tundra)	1 to 15
F′ (Frost)	0

The temperature efficiency was calculated for all stations in the United States for which precipitation effectiveness had already been determined. These were plotted on a map, and the isopleths bounding the provinces defined above were drawn (see Fig. 6).

[22] The equation for temperatures in the Centigrade scale is determined by substituting as follows:

$$T\,(°F) = 9/5\,T\,(°C) + 32$$

$$i'_c = \frac{[9/5\,T\,(°C) + 32] - 32}{4}$$

$$i'_c = \frac{9\,T\,(°C)}{20}$$

Summer Concentration of Thermal Efficiency

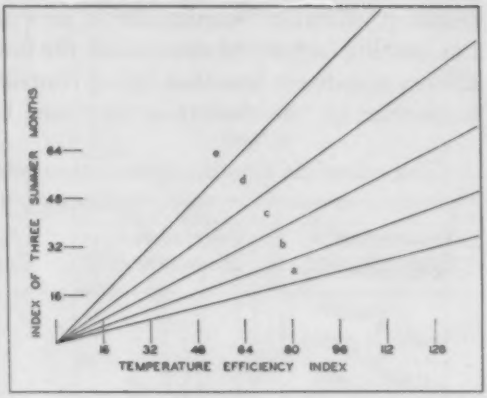

Fig. 8

The *T–E* index incompletely expresses the temperature relations of the climate because of local differences in the annual march of temperature. It is possible that in two stations having the same efficiency index one may have a gradual thermal summation throughout the whole year and the other a very rapid accumulation during a few summer months. In order to express this difference the ratio of the thermal efficiency accumulation of the three summer months to the total thermal efficiency has been calculated. Expressed in percentages these ratios range between 25 and 100, for obviously not less than 25 per cent of the total would be accumulated during the most favorable quarter of the year.

The index of summer concentration varies with latitude and with distance from the ocean. It is equivalent to annual range of temperature but is a more significant climatic factor than annual range. Although the annual range would be the same where the temperature varies between 0° F. and 40° F. as where it varies between 40° F. and 80° F., it is clear that the summer concentration in the latter case would be very much less than in the former.

On the basis of summer concentration of thermal efficiency five temperature subprovinces have been defined. They are the following:

Subprovince	Per Cent Summer Concentration
a	25 to 34
b	35 to 49
c	50 to 69
d	70 to 99
e	100

They may be determined by means of the chart (Fig. 8). In the United States only three of the five subdivisions occur (Fig. 7).

Elements of the Classification

Precipitation effectiveness and temperature efficiency are the two most significant climatic elements, and the relative importance of each depends upon its limiting effect. Where temperature efficiency is adequate, variations in precipitation effectiveness establish the

primary climatic boundaries: otherwise temperature efficiency is the limiting factor and determines the boundaries. If the temperature efficiency index is less than 32, it controls the climate; if the index is more than 32, the climate is controlled by precipitation effectiveness.

The complete classification makes use of the following symbols:

Precipitation Effectiveness	Temperature Efficiency	Rainfall Periodicity	Temperature Periodicity
A	A′	r	a
B	B′	s	b
C	C′	w	c
D	D′	d	d
E	E′		e
	F′		

Eight major climatic regions are recognized (see Fig. 9). They are as follows:

Temperature Efficiency Adequate	Temperature Efficiency Inadequate
A (Rain Forest)	D′ (Taiga)
B (Forest)	E′ (Tundra)
C (Grassland)	F′ (Perpetual snow and frost)
D (Steppe)	
E (Desert)	

Although there are variations of precipitation effectiveness in the regions where temperature efficiency is inadequate, these variations appear not to be significant and are therefore not considered. Thus, if the T–E index is less than 32, no further climatic analysis need be made; the climate is either D′, E′, or F′.

In the climates where precipitation effectiveness is the dominating factor there are three possible thermal subdivisions of each:

AA′	AB′	AC′
BA′	BB′	BC′
CA′	CB′	CC′
DA′	DB′	DC′
EA′	EB′	EC′

Further subdivision of the B, C, and D climates on the basis of seasonal distribution of precipitation is theoretically possible (see Fig. 5). Each of the three B climates may be divided into r, s, and w, each C climate into r, s, w, and d, and each D climate into s, w, and d. The A climates are always r, and the E climates are always d. Actually in the A′ subdivisions of B, C, and D the summer dry (s) modification never occurs. Certain other climates, theoretically possible

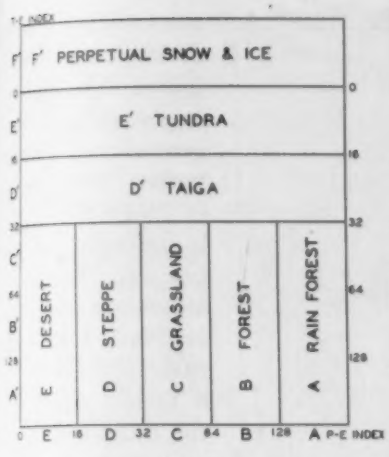

FIG. 9

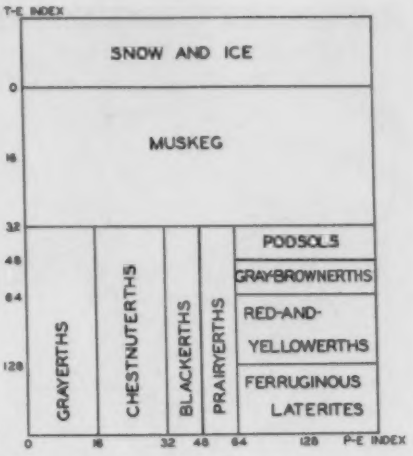

FIG. 10

FIG. 9—Graphical representation of the eight major climatic regions.
FIG. 10—Graphical representation of the climatic basis of soil development.

in this classification actually do not exist anywhere in North America or anywhere else on the earth.

The four stations for which climatological data follow are all in the C climates, but they illustrate the four types of seasonal distribution of precipitation. All four have an average annual rainfall of 22 inches but, because of differences in seasonal distribution, vary from 34 to 56 in precipitation effectiveness. For each station the P/E ratio of each month and the P–E index as well as the T–E index have been included. The symbol "%–s" refers to summer concentration of thermal efficiency.

CLIMATOLOGICAL DATA FOR TYPE STATIONS IN NORTH AMERICA

STATION		JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR	
CC'rb	T	31.7	34.0	39.1	46.4	52.7	62.0	67.4	66.2	60.6	50.6	41.4	31.8	48.7	T–E 50
Williams,	P	2.57	2.84	2.27	1.32	.89	.30	3.48	2.72	1.52	1.56	1.43	1.94	22.84	%–s 50
Ariz.	P/E	10.0	10.0	6.4	2.8	1.4	.4	4.8	3.8	2.2	2.8	3.6	7.6	56.00	P–E 56
CB'sa	T	50.0	52.3	53.6	55.2	56.5	58.5	58.5	59.0	61.2	60.3	56.3	51.2	56.1	T–E 72
San Fran-	P	4.90	3.63	3.20	1.49	.71	.15	.02	.02	.33	.96	2.53	4.58	22.52	%–s 29
cisco, Cal.	P/E	10.2	7.2	6.2	2.4	1.0	.2	.00	.00	.4	1.4	4.4	9.8	43.2	P–E 43
CB'wa	T	54.3	57.4	61.2	63.3	65.1	63.9	62.1	62.2	61.3	59.2	57.0	54.7	60.1	T–E 84
Mexico	P	.24	.24	.46	.71	1.93	3.88	4.49	4.48	4.09	1.58	.48	.30	22.91	%–s 27
City	P/E	.2	.2	.4	.8	2.6	5.8	7.2	7.2	6.4	2.4	.6	.2	34.0	P–E 34
CB'db	T	27.8	30.3	42.4	51.9	61.9	72.8	77.9	77.6	68.7	56.2	44.4	29.6	53.4	T–E 66
Phillips-	P	.41	.81	.79	2.33	3.01	3.91	3.03	2.80	2.60	1.50	.74	.60	22.73	%–s 50
burg, Kan.	P/E	1.6	3.2	1.8	4.4	4.6	5.0	3.4	3.2	3.4	2.4	1.8	3.2	37.0	P–E 37

THE CLIMATES OF NORTH AMERICA

On the continent of North America all of the primary and secondary climatic subdivisions and practically all of the tertiary and

GENERALIZED DISTRIBUTION OF CLIMATES IN NORTH AMERICA

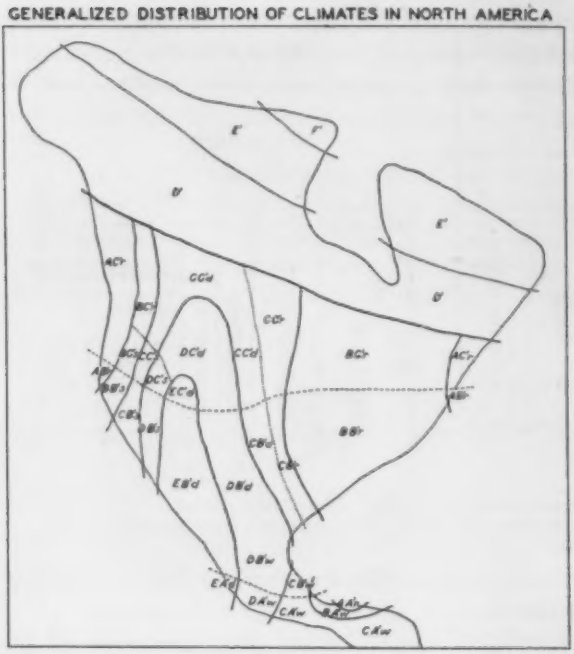

FIG. 11

quaternary subdivisions are to be found. A schematic diagram of the generalized distribution of climates in North America is presented in Figure 11. The climates are mapped in Plate III, and their distribution is briefly noted in the following paragraphs.[23]

THE A CLIMATES

Because of the irregular shape of the continent and the fact that only a small proportion of its area is in low latitudes, the various A climates are widely separated and are not extensive. A narrow strip of AA′ra is found in Mexico on the coast of the Gulf of Campeche, partly in Vera Cruz and partly in Tabasco. A small area occurs also in the elevated interior of Chiapas to the south of Tabasco. In the United States and Canada A climates occur on both the east and west coasts. AB′ra and AB′rb are extremely limited in area, a small section of the first on the northwest coast of California and of the second in the interior. A relatively small area of AB′rb occurs in the southern part of the Blue Ridge Mountains in western South Carolina and northern Georgia. The AC′rb and AC′rc climates are the most extensive in area. AC′rb extends along the west coast of America from the northern boundary of California to Sitka in Alaska and includes the westward-facing portions of the Coast Ranges of Oregon, Washington, and British Columbia as well as the western slopes of the Cascade Ranges and a portion of the Sierras in northern California. Only one small area of AC′rb is found in eastern America. It is in the higher elevations of the Blue Ridge Mountains of western North Carolina. AC′rc is found in four isolated areas in the Appalachians of the eastern United States, i.e. in West Virginia, in eastern Pennsylvania, and in the Catskills and Adirondacks of New York. The coastal portion of New Brunswick and most of Nova Scotia are AC′rc.

THE B CLIMATES

Comparatively small are the areas of B climates in Mexico. In the neighborhood of the Gulf of Campeche, parts of Vera Cruz, Chiapas, and Tabasco are BA′ra, and the inland section of Vera Cruz is BB′ra. On the west coast of Mexico a narrow strip along the coast of Guerrero and the coastal portion of Tepic is BA′wa. A small

[23] A considerable amount of computation is necessary to determine the P/E index for a station. The necessary data for 48 stations illustrating all the principal climatic types of North America are on file at the American Geographical Society and may be obtained upon request.

area in interior Tepic is BB'wa. Eastern United States and southeastern Canada are made up almost entirely of B climates. The southern tip of the Florida peninsula is BA'ra. A comparatively narrow belt of BB'ra extends along the coast of the Gulf of Mexico in eastern Texas, Louisiana, Mississippi, Alabama, Florida, and Georgia. The BB'rb climate includes the entire area from the eastern parts of Texas, Oklahoma, and Kansas to the Atlantic coast and north to Iowa and central Illinois. The northern portion of eastern United States and the southern portion of eastern Canada is BC'rc with the exception of a small strip extending from southern Ohio eastward across the Appalachians to the Atlantic seaboard, which is BC'rb. In western America the B climates are much less extensive than in the eastern part. From central California northward into British Columbia and eastward beyond the crest of the Sierras and the Cascades the areas not already accounted for as A are B. The areas in California and Oregon are BB'sb. In Washington the area to the west of the Cascades is BB'rb, while that to the east is BB'rc. In the interior western states certain elevated areas possess BC'rc climate.

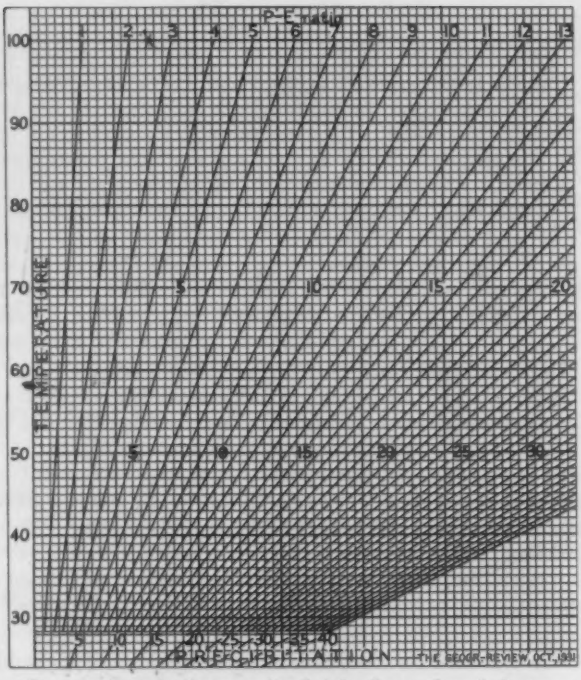

FIG. 12—Reproduction on reduced scale of a portion of the nomogram used in computing the *P-E* ratio (see p. 640).

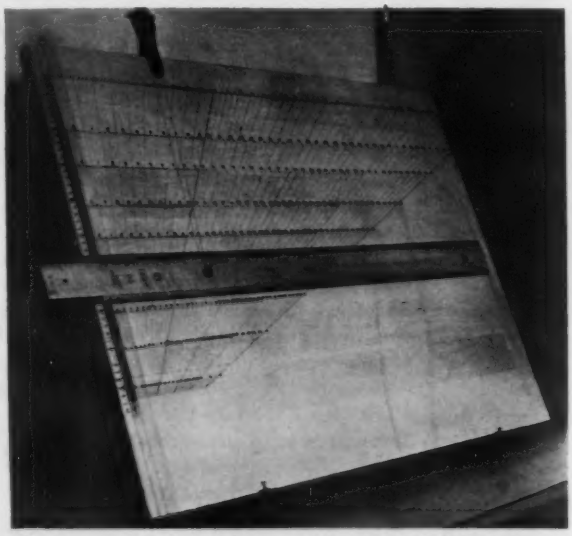

FIG. 13—Device for readily computing the *P-E* ratio—a homely contrivance made with a drawing board (on which the nomogram is constructed), T square, standard, weight, pulley, and fishline.

THE C CLIMATES

The C climates are the ones that are most variously subdivided. They extend from the Gulf of Mexico across to the Pacific in central and southern Mexico and extend north along the Sierra Madre Mountains to the border of Sonora in southwestern Chihuahua. Most extensive in Mexico are CA'wa and CB'wa. Near the Gulf coast in northern Vera Cruz and southern Tamaulipas are small areas of CA'... and CB'ra. More than half of the peninsular portion of Florida is CB'ra. Running from the Gulf of Mexico north through the central United States into Canada are two parallel belts of C climates; the eastern belt with precipitation adequate throughout the year and the western belt with precipitation inadequate. Through Texas, Oklahoma, and Kansas the climates are CB'rb and CB'db except for the coastal strip of Texas, where they become CB'ra and CB'da. North of Kansas and Missouri the climates are CC'rc and CC'dc. In Canada the rainy phase (CC'rc) is not extensive, including only a narrow strip of eastern Manitoba and a small corner of western Ontario, but the dry phase (CC'dc) extends in a wide belt from southwest Manitoba across Saskatchewan and Alberta into British Columbia, thence south into eastern Washington, central Idaho, and western Montana.

In the western United States the most conspicuous C climates are those with a dry summer season. The well known Mediterranean climate is subdivided in this classification into CB'sa and CB'sb which are roughly equivalent to Köppen's *Csa* and *Csb*. They occur principally in central California, but the CB'sb extends north up the Sacramento Valley as well and south along the west slopes of the Sierras into Baja California. Along the east slope of the Sierras a narrow strip of CC'sc extends from southern California across western Nevada and northeastern California into Oregon. Along the east slopes of the Cascades in Oregon and Washington the climate is CC'dc. Throughout the Rocky Mountains there are a number of areas with CC'dc climate. In central Utah, east of Great Salt Lake, there is a small area in which the CC'sc type is found.

THE D CLIMATES

In western North America the D climates occupy more area than any other climate. East of the Rockies they extend in a belt 300 to 600 miles wide from the latitude of Mexico City north across the United States and 300 miles into Saskatchewan and Alberta. In this strip nearly 2500 miles long only three subdivisions occur. In Mexico and in a portion of southern Texas DB'da is the type of climate encountered. From this area north to Kansas and southeastern Colorado the climate is DB'db. The area still to the north is DC'dc. In the more elevated portions of the Great Basin and the lower sections of the Rockies the climate is also DC'dc. A considerable portion of the San Joaquin Valley of California has DB'db climate, and the coast of southern California south of Los Angeles has DB'da climate. In southern California and the coastal valleys of central California certain limited areas lack only summer rainfall and are classified as DB'sa and DB'sb.

A short distance south of the border in Chihuahua in western Mexico there is a limited area of DB'wb. Elsewhere the steppe climates of western Mexico are of the DB'wa type. A narrow strip on the coast of Sinaloa falls into the DA'wa class.

THE E CLIMATES

Only two extensive continuously desert areas are to be found in North America. One includes the Laguna district of Chihuahua and Coahuila and small sections of Texas, New Mexico, and Arizona, extending up the Rio Grande some distance beyond Albuquerque. The southern part of this region is classed EB'da, and the northern part as EB'db. The second large desert region includes both coasts of the Gulf of California, with most of Baja California on the west and about half of Sonora

on the east. The region includes the southwestern third of Arizona, the eastern portion of California, and about half of Nevada. There are four subdivisions. In Mexico there is EA′da and EB′da, and in the United States EB′db and EC′db.

A number of other smaller desert areas are found in various localities in the western United States. The southern part of the San Joaquin Valley is EB′db. The other desert areas, wherever found, are EC′dc. They include an area in southeastern Washington, one in north-central Wyoming and another in southwestern Wyoming, one in the upper Rio Grande Valley in south-central Colorado, and two in Utah, the Great Salt Lake Desert of western Utah and the other in southeastern Utah.

THE D′ CLIMATES

The southern edge of the Taiga is very near the border of the United States where it makes its most southward extension in the Lake Superior region. This boundary crosses central Ontario and southern Quebec and reaches the Atlantic south of Newfoundland. To the west it crosses the central parts of Manitoba, Saskatchewan, and Alberta and dips rather far to the south in crossing the Rockies. West of the Rockies it parallels the coast for several degrees of latitude and finally reaches the Pacific across the Alexander Archipelago in Alaska. The northern boundary of the Taiga enters Alaska from Bering Sea some distance south of Nome. It is less than 200 miles from the Arctic until it crosses to the east of the Mackenzie River. It continues on southeast and reaches Hudson Bay between Fort Churchill and York Factory. The line reaches the Atlantic after crossing the northern part of Newfoundland. The D′ climate contains more area than any other single climatic type in North America.

THE E′ CLIMATES

The Tundra includes the Arctic coast and the area inland, in some places as much as 800 miles to the south, as well as most of the islands in the Arctic and the coastal portion of Greenland.

THE F′ CLIMATES

In none of the available records was a station with absolutely no thermal efficiency found. However, Fort Conger and Jones Sound have T–E indices of only 2. It is safe to infer that the edge of the F′ climate is near these stations, and hence its limits were drawn in approximately. The interior of Greenland and a part of Ellesmere Island are classed as F.′ It is probable that the F′ climate is somewhat more extensive than indicated, but in the absence of further data no additional interpretation was attempted.

The Climatic Basis of Plant Distribution

Ecologists have discovered that every distinctive climate produces characteristic plant associations. "These units, of vast extent and great permanence, are termed climaxes or formations; they are the product of climate and, hence, are controlled by it. Each formation is the highest type of vegetation possible under its particular climate. . . . The formation and climax are identical, and, hence, the same great community may be termed a formation, a climax, or for the sake of emphasis, a climax formation."[24]

The present climatic classification has been applied to the distribution of the climax formations as described and delimited by Weaver

[24] Weaver and Clements, *op cit.*, p. 421.

and Clements. In the following table the symbol of the climate that coincides with and ostensibly determined a particular climax is linked with the name of that climax.

CLIMAX FORMATIONS OF NORTH AMERICA

A. Tundra Climax
   1. Tundra: *Carex-Poa* Formation (E′)
B. Forest Climaxes
   1. Boreal Forest: *Picea-Larix* Formation (D′)
   2. Subalpine Forest: *Picea-Abies* Formation (D′)
   3. Lake Forest: *Pinus-Tsuga* Formation (BC′rc)
   4. Coast Forest: *Thuja-Tsuga* Formation (AC′ra, BC′sb)
   5. Montane Forest: *Pinus-Pseudotsuga* Formation (BC′rc)
   6. Deciduous Forest: *Quercus-Fagus* Formation (BB′rb)
C. Grassland Climax
   1. Prairie: *Stipa-Bouteloua* Formation (CB′rb, CC′rc) (CB′db, CC′dc)
D. Woodland Climax
   1. Woodland: *Pinus-Juniperus* Formation (CB′rb)
E. Scrub Climaxes
   1. Chaparral: *Quercus-Ceanothus* Formation (CB′sb)
   2. Sagebrush: *Atriplex-Artemisia* Formation (DC′dc)
   3. Desert Scrub: *Larrea-Franseria* Formation (EB′db)

The Climatic Basis of Soil Distribution

"The coincidence of soil belts and climatic belts has caused soil students to conclude that climatic forces are the predominant soil-forming agencies of the world," says Marbut,[25] summarizing the relation of soil to climate. In so far as soil regions have been determined in North America they seem to be related to precipitation effectiveness and temperature efficiency.

The climatic basis of soil development is presented graphically in Figure 10. In terms of precipitation effectiveness, in regions where temperature efficiency is adequate, two great groups of soils have developed. Where the *P–E* index is low the soluble materials are not leached out and carried away but are concentrated a short distance below the surface. These are called lime-accumulating soils, or pedocals. Where the *P–E* index is high the more soluble materials are rapidly leached away leaving only relative insoluble materials like iron and aluminum. These are called aluminum-and-iron-accumulating soils, or pedalfers. The *P–E* index of 48 separates these great soil groups. The *P–E* isopleths of 16 and 32 divide the pedocals into three regions designated as grayerths, chestnuterths, and blackerths. The *P–E* isopleth of 64 separates the prairyerths from the forest soils of the more humid regions. The pedalfers that develop

[25] H. L. Shantz and C. F. Marbut: The Vegetation and Soils of Africa, *Amer. Geogr. Soc. Research Ser. No. 13*, New York, 1923, p. 120.

The American Geographical Society of New York

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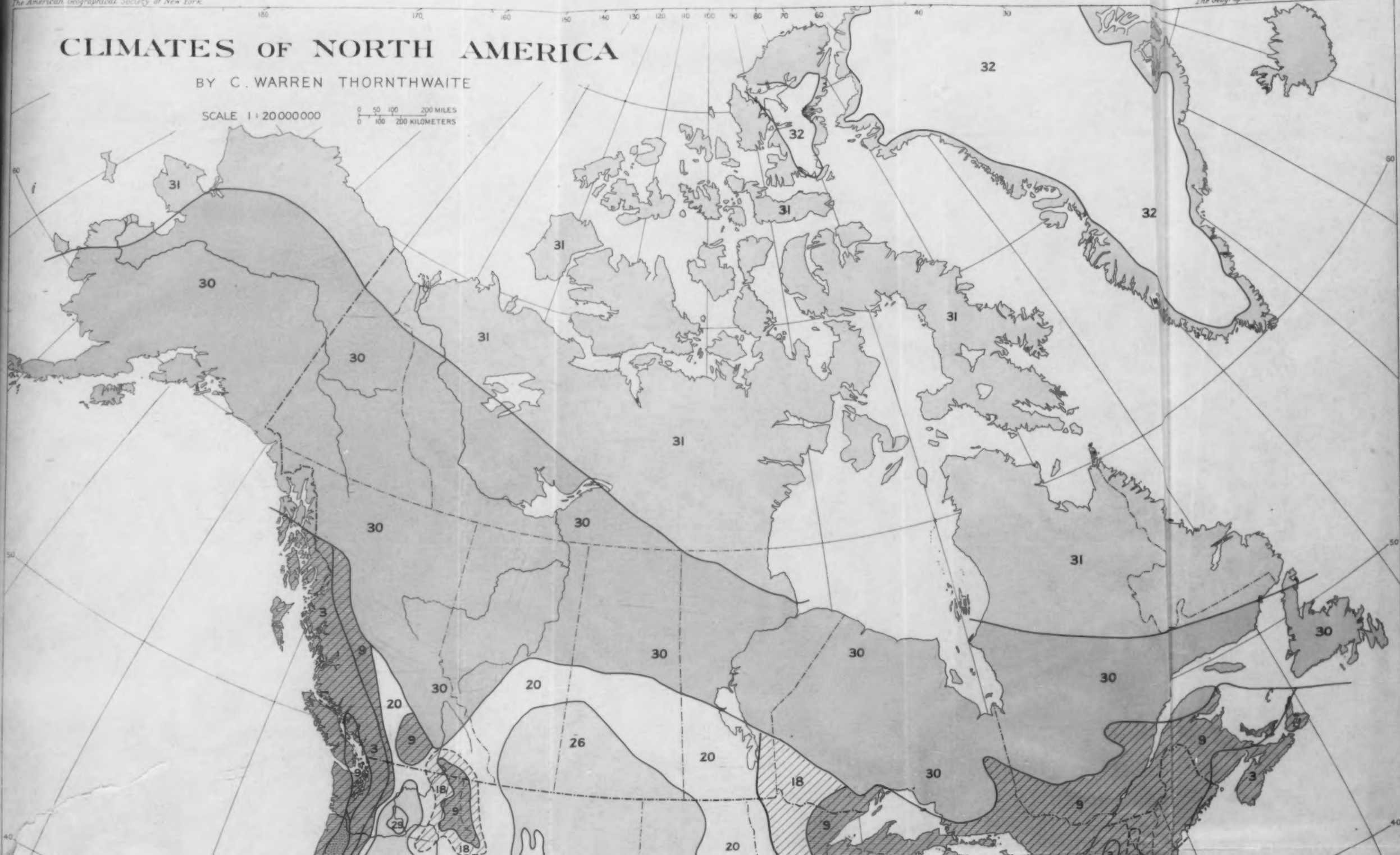
CLIMATES OF NORTH AMERICA

BY C. WARREN THORNTHWAITE

SCALE 1 : 20000000

0 50 100 200 MILES
0 100 200 KILOMETERS



CLIMATIC PROVINCES

1	AA'r	2	AB'r	3	AC'r
4	BA'r	6	BB'r	9	BC'r
5	BA'w	7	BB'w	10	BC'w
		8	BB's	11	BC's
12	CA'r	14	CB'r	18	CC'r
13	CA'w	15	CB'w		
		16	CB's	19	CC's
		17	CB'd	20	CC'd
21	DA'w	23	DB'w		
		24	DB's		
22	DA'd	25	DB'd	26	DC'd
27	EA'd	28	EB'd	29	EC'd
30	D'	31	E'	32	F'

KEY TO SYMBOLS

HUMIDITY PROVINCE

- A *Wet*
- B *Humid*
- C *Sub-humid*
- D *Semiarid*
- E *Arid*

TEMPERATURE PROVINCE

- A' *Tropical*
- B' *Mesothermal*
- C' *Microthermal*
- D' *Taiga*
- E' *Tundra*
- F' *Frost*

T/E *index of 48*

SEASONAL DISTRIBUTION OF PRECIPITATION

- r *adequate at all seasons*
- s *summer deficiency*
- w *winter deficiency*
- d *deficiency at all seasons*

Examples: **AA'r** *wet, tropical climate with adequate moisture at all seasons (Southern Vera Cruz)*
DB's *semiarid, mesothermal, summer dry climate (Los Angeles)*

Equal-Area Azimuthal Projection

ht, 1931, by the American Geographical Society of New York

LITHO A. HOEN & CO. INC.

where the P–E index is greater than 64 are subdivided on the basis of temperature efficiency. The T–E isopleths of 48, 64, and 128 separate the forest pedalfers into four soil groups named podsols, gray-brownerths, red-and-yellowerths, and ferruginous laterites.[26] The soils in the tundra and cold half of the taiga (where the T–E index is less than 24) are, in this study, called muskeg, after the most characteristic surface feature. Soils and climates are associated somewhat as follows.

I. Pedocals
   1. Grayerths (EA′, EB′, EC′)
   2. Brownerths (DA′, DB′, DC′)
   3. Chestnuterths (DA′, DB′, DC′)
   4. Blackerths (CA′d, CB′d, CC′d)

II. Pedalfers
   1. Prairyerths (CA′r, CB′r, CC′r)
   2. Podsols (BC′, AC′)
   3. Gray-brownerths (BC′, AC′)
   4. Red-and-yellowerths (BB′, AB′)
   5. Ferruginous laterites (BA′, AA′)

III. Muskeg (D′, E′)

Conclusion

Geographers, ecologists and soil scientists for the most part have been working independently each in ignorance of the discoveries made by the other group. Yet it is evident that the distributions of the soils and vegetational elements of the natural landscape are causally interrelated, as well as causally related to climate. It is hoped that soil science and ecology may find in this classification a common ground which may bring them together and which can be used in the explanation of climax formations and mature soils. It is not suggested that the climatic classification here presented is in its final form or is satisfactory in every detail. It is believed, however, that the climatic elements of the landscape are here analyzed with a greater precision than has heretofore been attained. Köppen's scheme brings out the general relations of vegetation and soil to climate over the earth but fails in detailed local analyses: the present classification in so far as it has been tested has been found to work as well in detailed as in general analyses. The ultimate value of the general classification will not be known until the climatic regions of the whole earth are mapped and are compared with the distributions of the various elements of the natural landscape. In the meantime it is hoped that other geographers may be inspired to make further studies of climate on a quantitative basis.

[26] The soil nomenclature is that proposed by Wolfanger. It is not satisfactory but is used here in the absence of a better one.

SEASONAL VARIATIONS IN DAYLIGHT, TWILIGHT, AND DARKNESS

S. W. Boggs

Department of State, Washington, D. C.

THE diurnal and seasonal variations in daylight, twilight, and darkness are rather difficult to comprehend without the aid of apparatus or graphic devices. These diagrams and tables were designed to visualize and emphasize some of the facts relating to twilight, but they may prove to be of more general interest.

The tables upon which the present brief study is based appeared in "General Tide Tables for the Year 1916," published by the U. S. Coast and Geodetic Survey. This publication contains the only table giving the time of beginning of morning twilight (or dawn), and of the end of evening twilight, which the writer found available. It should be noted that the tables are constructed as a practical aid to the mariner, the supposition being that the observer's eye is 15 feet above the surface of the sea (or the plane of the land). The sunrise and sunset tables give the time of appearance and disappearance of the *upper limb* (not the center) of the sun, as actually seen from an elevation of 15 feet above the horizon.

At any moment it is daylight over slightly more than half the earth; if the fringe on which the sun is either rising or setting be included, at least a portion of the sun is above the horizon over 50.8 per cent of the earth's surface. Not all of the remaining 49.2 per cent is enveloped in total darkness, however. Approximately 15.4 per cent of the total surface lies in the belt of "astronomical twilight," which is lighted to a greater or lesser degree by the refracted rays of the sun when it is not more than 18° (by the usual definition) below the horizon. The belt of "civil twilight" is only one-third as wide, comprising the zone within which the sun is not more than 6° below the horizon, approximately 4.4 per cent of the earth's surface. Total darkness, so far as the sun is concerned, envelops only about 34 per cent of the earth's surface at any moment and grades off insensibly through the twilight toward daylight.

The formula used in computing the mean local civil time of sunrise and sunset takes into consideration the latitude, the sun's declination, and the sun's zenith distance. The latter is used as a constant, with a value of 90° 56′ 09″, the excess above 90° being due principally to the refraction of the sun's rays in the horizon (36′ 29″) and to the sun's semidiameter (16′ 01″), allowance also being made for the sun's horizontal parallax (0′ 09″, subtracted), and for the dip of the horizon for a height of 15 feet (3′ 48″). Variations of refraction in the horizon produce a sensible change in the time of rising or setting of the sun, but it is impossible to estimate these variations in advance. Under extreme changes in atmospheric temperature and pressure, refraction in the horizon may vary about 8′ either way from the mean value used in the formula, but this would make only a few seconds difference in the time of sunrise or sunset near the equator. It would, however, amount to a whole minute of time in latitude 48° at the time of the local summer solstice, to two minutes in latitude 61°, and would increase rapidly toward the pole.

There are also differences in the duration of sunlight for the forenoon and afternoon of the same day which, in higher latitudes, amount at times to more than half an hour. Close study of the detailed tables furthermore reveals minor variations between comparable dates, as in times of sunrise and sunset at the time of the two equinoxes in points of opposite and equal latitude.

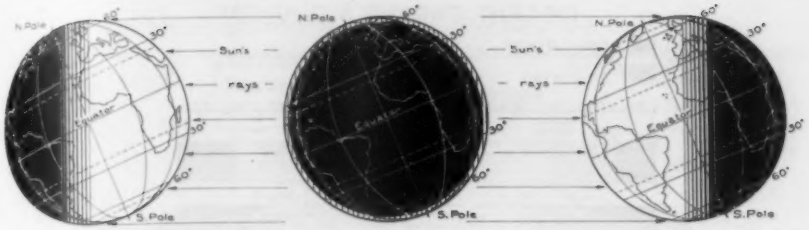


FIG. 1—The lighting of the earth as seen from a point in space in the plane of the orbit at an infinite distance from the earth, the sun in a direct line behind the central sphere. Left (a), solstice, December 22; center (b) equinox, March 21; right (c) solstice, June 21. The belt of "astronomical twilight" encircling the earth is shaded.

In Table I only the average times are shown. For example, there is at the equator, of course, a minimum seasonal variation, but the table would make it appear that there is none whatever in the hours of sunrise and sunset. Actually the time of sunrise varies from 5.40 a. m. (about Nov. 1) to 6.11 a. m. (about Feb. 15) at the equator. Appreciably greater variations for the higher latitudes have been averaged in arriving at the figures which appear in Table I.

Table II is derived from Table I and brings out more strikingly the seasonal contrasts in different latitudes. The data in the second column appear not to accord with the definition of the equinox as the time at which day and night are everywhere of equal length. The sun's zenith distance of 90° 56′ 09″, rather than 90°, however, accounts for the slightly longer period of daylight toward both poles than at the equator at the time of the equinox. And the period of more than 11 hours twilight in 80° latitude, simultaneously in both polar regions at that time, contrasts with the period of 2 hours 16 minutes twilight at the equator.

TABLE I—SUNRISE, SUNSET, AND TWILIGHT (AVERAGE OR MEAN LOCAL TIME)

LATITUDE (N. AND S.)		SUMMER SOLSTICE	EQUINOX	WINTER SOLSTICE
90°		(a)	(a)	(b)
80°	Beginning twilight	(a)	(c)	8.07 a.m.
	Sunrise		5.38 a.m.	(d)
	Sunset		6.22 p.m.	(d)
	End twilight		(c)	3.53 p.m.
60°	Beginning twilight	(c)	3.25 a.m.	6.18 a.m.
	Sunrise	2.33 a.m.	5.53 a.m.	9.03 a.m.
	Sunset	9.27 p.m.	6.07 p.m.	2.57 p.m.
	End twilight	(c)	8.35 p.m.	5.42 p.m.
30°	Beginning twilight	3.22 a.m.	4.36 a.m.	5.29 a.m.
	Sunrise	4.57 a.m.	5.56 a.m.	6.53 a.m.
	Sunset	7.03 p.m.	6.04 p.m.	5.07 p.m.
	End twilight	8.38 p.m.	7.24 p.m.	6.31 p.m.
0°	Beginning twilight	4.41 a.m.	4.48 a.m.	4.41 a.m.
	Sunrise	5.56 a.m.	5.56 a.m.	5.56 a.m.
	Sunset	6.04 p.m.	6.04 p.m.	6.04 p.m.
	End twilight	7.19 p.m.	7.12 p.m.	7.19 p.m.

(a) Sun does not set.
(b) Sun remains more than 18° below the horizon.
(c) Sun does not go as much as 18° below the horizon.
(d) Sun does not rise; twilight lasts from morning to evening, being strongest at noon.

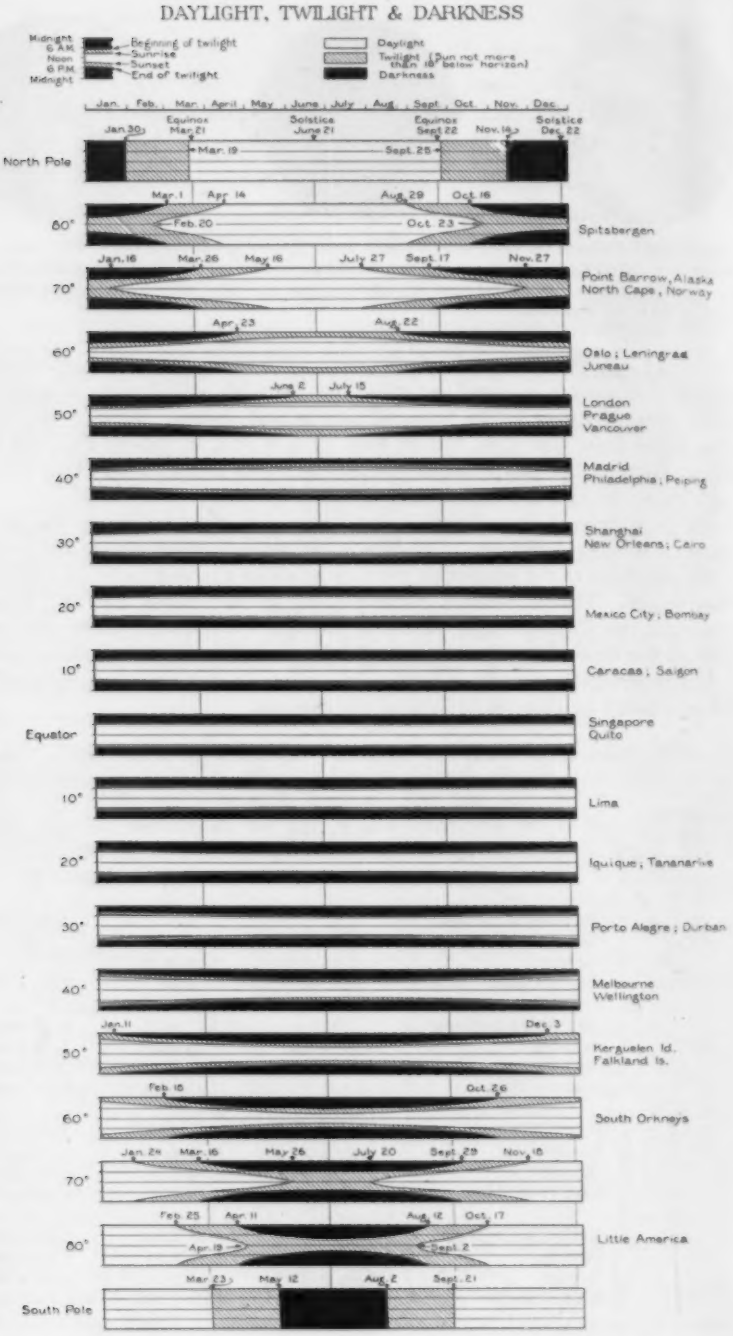

DAYLIGHT, TWILIGHT & DARKNESS
Midnight
6 A.M.
Noon
6 P.M.
Midnight
Beginning of twilight
Sunrise
Sunset
End of twilight
Daylight
Twilight (Sun not more than 18° below horizon)
Darkness
Jan. , Feb. , Mar. , April , May , June , July , Aug. , Sept. , Oct. , Nov. , Dec.
Jan. 30
Equinox Mar. 21
Solstice June 21
Equinox Sept. 22
Nov. 18
Solstice Dec. 22
North Pole
Mar. 19
Sept. 25
Mar. 1
Apr. 14
Aug. 29
Oct. 16
80°
Feb. 20
Oct. 23
Spitsbergen
Jan. 16
Mar. 26
May 16
July 27
Sept. 17
Nov. 27
70°
Point Barrow, Alaska
North Cape, Norway
Apr. 23
Aug. 22
60°
Oslo; Leningrad
Juneau
June 2
July 15
50°
London
Prague
Vancouver
40°
Madrid
Philadelphia; Peiping
30°
Shanghai
New Orleans; Cairo
20°
Mexico City; Bombay
10°
Caracas; Saigon
Equator
Singapore
Quito
10°
Lima
20°
Iquique; Tananarive
30°
Porto Alegre; Durban
40°
Melbourne
Wellington
Jan. 11
Dec. 3
50°
Kerguelen Id.
Falkland Is.
Feb. 16
Oct. 26
60°
South Orkneys
Jan. 24
Mar. 16
May 26
July 20
Sept. 29
Nov. 16
70°
Feb. 25
Apr. 11
Aug. 12
Oct. 17
80°
Apr. 19
Sept. 2
Little America
Mar. 23
May 12
Aug. 2
Sept. 21
South Pole

FIG. 2

TABLE II—DURATION OF DAYLIGHT, TWILIGHT, AND DARKNESS

LATITUDE (N. AND S.)		SUMMER SOLSTICE		EQUINOX		WINTER SOLSTICE	
		Hours	Minutes	Hours	Minutes	Hours	Minutes
90°	Daylight	24	0	24	0	..	..
	Twilight	..	..	..	..	..	..
	Darkness	..	..	..	..	24	0
80°	Daylight	24	0	12	44	..	..
	Twilight	..	..	11	16	7	46
	Darkness	..	..	..	..	16	14
60°	Daylight	18	54	12	14	5	54
	Twilight	5	6	4	56	5	30
	Darkness	..	..	6	50	12	36
30°	Daylight	14	6	12	8	10	14
	Twilight	3	10	2	40	2	48
	Darkness	6	44	9	12	10	58
0°	Daylight	12	8	12	8	12	8
	Twilight	2	30	2	16	2	30
	Darkness	9	22	9	36	9	22

In Figure 1 the reasons for the great variations in the duration of daylight and twilight are graphically indicated. The belt of "astronomical twilight" encircles the earth just beyond the half which is in sunlight. By definition it is 18° of arc in width beyond the exact one-half of the earth's surface most directly lighted by the sun. The situation at the time of the two solstices is illustrated on the two extreme spheres, (*a*) and (*c*). In the middle sphere, (*b*), the twilight belt appears to be narrower than on the spheres on either side, for the reason that, as seen by the eye from an infinite distance, points a given distance apart when situated near the horizon subtend a much smaller angle than when situated in the center of the visible hemisphere.

It is readily seen that the twilight zone, 1250 miles in width, covers a much wider extent of longitude in the higher latitudes than near the equator, at all seasons of the year. It is true that at the time of the winter solstice the twilight belt does not quite reach the pole, but it does extend appreciably beyond 80° latitude. At that time the belt of twilight covers nearly one-third of the longitudinal extent of the 80° parallel, resulting in 7 hours 46 minutes of twilight, even though the sun never rises, and when the remaining two-thirds of the twenty-four hours is enveloped in total darkness so far as the sun is concerned.

The preceding observations introduce Figure 2. Properly understood, it speaks for itself and compresses a great deal of information within small compass. For each 10° of latitude it presents a continuous picture of the distribution of daylight, twilight, and darkness for every day in the year. It will be noted that the vertical scale (shown at the top of the diagram) represents the twenty-four hours of the day, and indicates the time of sunrise and sunset and of the beginning and end of twilight. The horizontal scale is true to the calendar lengths of the various months. The diagram was plotted at intervals of fifteen days directly from the sunrise-sunset and twilight tables published by the Coast and Geodetic Survey. So far as the vertical scale of the diagram permits, the hours of sunrise and sunset and of the beginning of morning twilight and end of evening twilight may be read graphically for any day of the year for the latitudes shown.

ADDITIONAL NOTES ON "PLANETABLING FROM THE AIR"

O. M. Miller

American Geographical Society's School of Surveying

THE following note is supplementary to the article entitled "Planetabling from the Air" appearing in the April number of the *Geographical Review*. In this article it was assumed that, provided the horizontal on the photograph had been correctly indicated, the rectangular coördinate measurements made on the photograph, converted into angles by the simple tangent formulae given, corresponded to the horizontal and vertical angles at the air station between the optical axis of the camera and the points on the ground. These approximations are justifiable only under certain conditions.

Following the notation used in the original paper, let a be the difference between the angle of tilt, D, and the angle of elevation or depression of a ray from the camera station to a point in nature, and let b be the true horizontal angle between the principal plane and this ray.

Let $\tan a' = \frac{v}{f}$ and $\tan b' = \frac{s}{f}$. Then it can be shown that

$$\tan (a \pm D) = \tan (a' \pm D) \cos b \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1a)$$

and

$$\tan b = \frac{\tan b' \cos a'}{\cos (a' \pm D)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2a)^1$$

It is apparent from the formulae that b equals b' all over a photograph only when the optical axis has been horizontal at the time of exposure; that, when the camera axis is tilted, b equals b' only along a horizontal line at an angular distance halfway between the horizon and the axis of tilt; and that, no matter what the tilt, a equals a' only for points lying in the principal plane.

However, provided that the tilt is not too great and the points on the photographs to be utilized for plotting lie somewhere near either the trace of the principal plane or the traces of the horizon and the axis of the tilt, the originally proposed approximate values a' and b' are sufficient for the purposes of making a rough small-scale reconnaissance map. If the horizon appears about three-quarters of the way up the photograph the average tilt will be about 10°, and only the location of those points in the landscape appearing in the lower corners of the photograph will be grossly in error. These points will presumably be fairly close to the air station; and in reconnaissance work, as the air station will be resected most probably from distant points, the errors introduced by the approximation will be largely localized.

For greater precision it is proposed to make corrections to the a' and b' angles by means of tables giving the differences between the true and the approximate angles. Tables I and II are examples of such, and it will be noted that Table II is applicable for any tilt provided it is further extended.

To use the tables an approximate value of the angle of tilt D is sufficient; but, in applying the corrected angle a to D in order to obtain the true vertical angle of a

[1] For a discussion of the theory underlying these formulae see L. N. F. I. King: Graphical Methods of Plotting from Air Photographs, Professional Papers of the British Air Survey Committee, No. 1. London, 1925, Section 14, Ch. 3, pp. 17–19.

ray from the horizontal, a more precise value of D must be used. This, however, will have been obtained with considerable accuracy by means of the formulae 3 to 7 given in the original paper.

Again, in the preliminary working of these formulae an approximate value of D must be taken in order that the a and b angles can be corrected; but this can be obtained with sufficient accuracy from the flight records and by an intelligent inspection of the photograph.

Examples of Using Tables

D	−10°	−10°	−10°	−10°
a'	+2°40′	+13°20′	−2°40′	−8°20′
b'	17°30′	17°30′	17°30′	17°30′
Interpolated correction from Table I	+07′	−24′	+24′	+43′
b	17°37′	17°06′	17°54′	18°13′
$a' \pm D$	−7°20′	+3°20′	−12°40′	−18°20′
Interpolated correction from Table II	+21′	−09′	+36′	+52′
a	+3°01′	+13°11′	−2°04′	−7°28′

It should be possible to refine the method further by the use of an angle-measuring device which, when properly adjusted for focal length, will read the a and b angles directly. Finally, it should be pointed out that if considerable precision is desirable the horizontal position of the air station relative to three or more known ground-control points can be computed by ordinary trigonometrical methods once the b angles have been properly obtained.

Table I—Difference between b and b' When D = −10°

	a'	b'	30°	28°	26°	24°	22°	20°	18°	16°	14°	12°	10°	8°	6°	4°	2°	0
	+20°		1°09′	1°06′	1°03′	50′	55′	51′	46′	42′	37′	32′	27′	22′	16′	11′	5′	0
	+18°		50′	57′	54′	51′	48′	44′	40′	36′	32′	28′	23′	19′	14′	10′	5′	0
	+16°		50′	48′	45′	43′	40′	37′	34′	31′	27′	24′	20′	16′	12′	8′	4′	0
	+14°		41′	39′	37′	35′	33′	30′	28′	25′	22′	19′	16′	13′	10′	7′	3′	0
	+12°		32′	31′	29′	28′	26′	23′	21′	19′	17′	15′	12′	10′	8′	6′	2′	0
Horizon	+10°		23′	22′	21′	20′	18′	16′	15′	13′	12′	10′	9′	7′	5′	4′	2′	0
	+8°		14′	13′	13′	12′	11′	10′	9′	8′	7′	6′	5′	4′	3′	2′	−1′	0
	+6°		−4′	−4′	−4′	−4′	−4′	−3′	−3′	−3′	−2′	−2′	−2′	−1′	−1′	−1′	0	0
	+4°		+5′	+4′	+4′	+4′	+4′	+3′	+3′	+3′	+3′	+2′	+2′	+1′	+1′	+1′	0	0
	+2°		14′	13′	13′	12′	11′	10′	9′	8′	7′	6′	5′	4′	3′	2′	+1′	0
Axis of Tilt	0°		23′	22′	21′	20′	18′	17′	15′	14′	13′	11′	9′	7′	5′	4′	2′	0
	−2°		32′	31′	30′	28′	26′	24′	21′	20′	18′	16′	13′	10′	8′	6′	3′	0
	−4°		42′	40′	38′	36′	33′	31′	28′	26′	23′	20′	16′	13′	10′	7′	3′	0
	−6°		51′	49′	47′	44′	41′	38′	35′	32′	28′	24′	20′	16′	12′	8′	4′	0
	−8°		1°01′	59′	56′	53′	49′	46′	42′	38′	33′	29′	24′	19′	15′	10′	5′	0
	−10°		1°11′	1°08′	1°05′	1°01′	57′	53′	49′	44′	39′	33′	28′	22′	17′	12′	6′	0
	−12°		1°21′	1°18′	1°14′	1°10′	1°05′	1°00′	55′	50′	44′	38′	32′	26′	20′	13′	7′	0
	−14°		1°31′	1°28′	1°24′	1°19′	1°14′	1°08′	1°02′	56′	50′	43′	36′	29′	22′	15′	7′	0
	−16°		1°42′	1°38′	1°33′	1°28′	1°22′	1°16′	1°10′	1°03′	56′	49′	41′	33′	25′	16′	8′	0
	−18°		1°53′	1°48′	1°43′	1°37′	1°31′	1°24′	1°17′	1°10′	1°02′	54′	45′	36′	28′	18′	9′	0
	−20°		2°04′	1°59′	1°53′	1°47′	1°40′	1°33′	1°25′	1°17′	1°08′	59′	50′	40′	30′	20′	10′	0

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and

$$\tan b = \frac{\tan b' \cos a'}{\cos (a' \pm D)} \qquad (2a)^1$$

It is apparent from the formulae that b equals b' all over a photograph only when the optical axis has been horizontal at the time of exposure; that, when the camera axis is tilted, b equals b' only along a horizontal line at an angular distance halfway between the horizon and the axis of tilt; and that, no matter what the tilt, a equals a' only for points lying in the principal plane.

However, provided that the tilt is not too great and the points on the photographs to be utilized for plotting lie somewhere near either the trace of the principal plane or the traces of the horizon and the axis of the tilt, the originally proposed approximate values a' and b' are sufficient for the purposes of making a rough small-scale reconnaissance map. If the horizon appears about three-quarters of the way up the photograph the average tilt will be about 10°, and only the location of those points in the landscape appearing in the lower corners of the photograph will be grossly in error. These points will presumably be fairly close to the air station; and in reconnaissance work, as the air station will be resected most probably from distant points, the errors introduced by the approximation will be largely localized.

For greater precision it is proposed to make corrections to the a' and b' angles by means of tables giving the differences between the true and the approximate angles. Tables I and II are examples of such, and it will be noted that Table II is applicable for any tilt provided it is further extended.

To use the tables an approximate value of the angle of tilt D is sufficient; but, in applying the corrected angle a to D in order to obtain the true vertical angle of a

[1] For a discussion of the theory underlying these formulae see L. N. F. I. King: Graphical Methods of Plotting from Air Photographs, Professional Papers of the British Air Survey Committee, No. 1, London, 1925, Section 14, Ch. 3, pp. 17–19.

ray from the horizontal, a more precise value of D must be used. This, however, will have been obtained with considerable accuracy by means of the formulae 3 to 7 given in the original paper.

Again, in the preliminary working of these formulae an approximate value of D must be taken in order that the a and b angles can be corrected; but this can be obtained with sufficient accuracy from the flight records and by an intelligent inspection of the photograph.

Examples of Using Tables

D	−10°	−10°	−10°	−10°
a'	+2°40′	+13°20′	−2°40′	−8°20′
b'	17°30′	17°30′	17°30′	17°30′
Interpolated correction from Table I	+07′	−24′	+24′	+43′
b	17°37′	17°06′	17°54′	18°13′
$a' \pm D$	−7°20′	+3°20′	−12°40′	−18°20′
Interpolated correction from Table II	+21′	−09′	+36′	+52′
a	+3°01′	+13°11′	−2°04′	−7°28′

It should be possible to refine the method further by the use of an angle-measuring device which, when properly adjusted for focal length, will read the a and b angles directly. Finally, it should be pointed out that if considerable precision is desirable the horizontal position of the air station relative to three or more known ground-control points can be computed by ordinary trigonometrical methods once the b angles have been properly obtained.

Table I—Difference between b and b' When D = −10°

	a'	b'	30°	28°	26°	24°	22°	20°	18°	16°	14°	12°	10°	8°	6°	4°	2°	0
	+20°		1°00′	1°06′	1°03′	59′	55′	51′	46′	42′	37′	32′	27′	22′	16′	11′	5′	0
	+18°		59′	57′	54′	51′	48′	44′	40′	36′	32′	28′	23′	19′	14′	10′	5′	0
	+16°		50′	48′	45′	43′	40′	37′	34′	31′	27′	24′	20′	16′	13′	8′	4′	0
	+14°		41′	39′	37′	35′	33′	30′	28′	25′	22′	19′	16′	13′	10′	7′	3′	0
	+12°		32′	31′	29′	28′	26′	23′	21′	19′	17′	15′	12′	10′	8′	6′	2′	0
Horizon	+10°		23′	22′	21′	20′	18′	16′	15′	13′	12′	10′	9′	7′	5′	4′	2′	0
	+8°		14′	13′	13′	12′	11′	10′	9′	8′	7′	6′	5′	4′	3′	2′	−1′	0
	+6°		−4′	−4′	−4′	−4′	−4′	−3′	−3′	−3′	−2′	−2′	−2′	−1′	−1′	−1′	0	0
	+4°		+5′	+4′	+4′	+4′	+4′	+3′	+3′	+3′	+3′	+2′	+2′	+1′	+1′	+1′	0	0
	+2°		14′	13′	13′	12′	11′	10′	9′	8′	7′	6′	5′	4′	3′	2′	+1′	0
Axis of Tilt	0°		23′	22′	21′	20′	18′	17′	15′	14′	13′	11′	9′	7′	5′	4′	2′	0
	−2°		32′	31′	30′	28′	26′	24′	21′	20′	18′	16′	13′	10′	8′	6′	3′	0
	−4°		42′	40′	38′	36′	33′	31′	28′	26′	23′	20′	16′	13′	10′	7′	3′	0
	−6°		51′	49′	47′	44′	41′	38′	35′	32′	28′	24′	20′	16′	12′	8′	4′	0
	−8°		1°01′	59′	56′	53′	49′	46′	42′	38′	33′	29′	24′	19′	15′	10′	5′	0
	−10°		1°11′	1°08′	1°05′	1°01′	57′	53′	49′	44′	39′	33′	28′	22′	17′	12′	6′	0
	−12°		1°21′	1°18′	1°14′	1°10′	1°05′	1°00′	55′	50′	44′	38′	32′	26′	20′	13′	7′	0
	−14°		1°31′	1°28′	1°24′	1°19′	1°14′	1°08′	1°02′	56′	50′	43′	36′	29′	22′	15′	7′	0
	−16°		1°42′	1°38′	1°33′	1°28′	1°22′	1°16′	1°10′	1°03′	56′	49′	41′	33′	25′	16′	8′	0
	−18°		1°53′	1°48′	1°43′	1°37′	1°31′	1°24′	1°17′	1°10′	1°02′	54′	45′	36′	28′	18′	9′	0
	−20°		2°04′	1°59′	1°53′	1°47′	1°40′	1°33′	1°25′	1°17′	1°08′	59′	50′	40′	30′	20′	10′	0

TABLE II—DIFFERENCE BETWEEN a AND a'

$a' \pm D$	b	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	28°	29°	30°
0°		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1°		0	0	0	0	0	0	0	0	0	1′	1′	1′	1′	2′	2′	2′	2′	2′	3′	3′	3′	4′	4′	4′	5′	6′	6′	7′	8′	8′	8′
2°		0	0	0	0	0	0	0	1′	1′	1′	1′	2′	2′	3′	3′	4′	4′	5′	6′	6′	7′	8′	9′	10′	11′	12′	13′	14′	15′	16′	16′
3°		0	0	0	0	0	1′	1′	1′	2′	2′	3′	3′	4′	5′	5′	6′	7′	8′	9′	10′	11′	12′	14′	15′	16′	17′	18′	20′	21′	22′	24′
4°		0	0	0	0	1′	1′	1′	2′	3′	3′	4′	5′	5′	6′	7′	8′	9′	10′	12′	13′	14′	16′	18′	19′	21′	22′	24′	26′	28′	30′	32′
5°		0	0	0	0	1′	1′	2′	2′	3′	4′	5′	6′	7′	8′	9′	10′	12′	13′	15′	16′	18′	20′	22′	24′	26′	28′	30′	33′	35′	37′	40′
6°		0	0	0	0	1′	1′	2′	3′	4′	5′	6′	7′	8′	9′	10′	12′	14′	16′	18′	20′	22′	24′	26′	28′	31′	33′	36′	39′	42′	45′	48′
7°		0	0	0	0	1′	2′	2′	3′	4′	5′	6′	8′	10′	11′	12′	14′	16′	18′	21′	23′	25′	27′	30′	33′	36′	39′	42′	45′	49′	52′	56′
8°		0	0	0	0	1′	2′	3′	4′	5′	6′	7′	9′	11′	12′	14′	16′	18′	21′	24′	26′	28′	31′	35′	38′	41′	44′	48′	52′	56′	1°00′	1°03′
9°		0	0	0	0	1′	2′	3′	4′	5′	6′	8′	10′	12′	14′	16′	18′	20′	23′	26′	29′	32′	35′	39′	43′	46′	50′	54′	58′	1°03′	1°07′	1°11′
10°		0	0	0	0	1′	2′	3′	4′	5′	6′	7′	9′	11′	13′	15′	17′	20′	23′	26′	29′	32′	35′	39′	43′	47′	51′	55′	1°00′	1°04′	1°09′	1°14′	1°19′
11°		0	0	0	0	1′	2′	4′	5′	6′	7′	8′	10′	12′	14′	16′	19′	22′	25′	28′	31′	35′	39′	43′	47′	52′	56′	1°01′	1°06′	1°10′	1°16′	1°21′	1°27′
12°		0	0	0	0	1′	2′	3′	4′	6′	7′	9′	11′	13′	15′	18′	21′	24′	27′	30′	34′	38′	43′	47′	51′	56′	1°01′	1°06′	1°11′	1°16′	1°22′	1°28′	1°34′
13°		0	0	0	0	1′	2′	3′	5′	6′	8′	10′	12′	14′	17′	19′	23′	26′	29′	33′	37′	41′	46′	50′	55′	1°00′	1°06′	1°11′	1°17′	1°22′	1°29′	1°35′	1°42′
14°		0	0	0	1′	2′	3′	5′	6′	8′	10′	13′	15′	18′	21′	24′	28′	31′	35′	39′	44′	49′	54′	59′	1°05′	1°10′	1°16′	1°22′	1°28′	1°35′	1°42′	1°49′
15°		0	0	1′	1′	2′	3′	5′	6′	8′	11′	13′	16′	19′	22′	26′	29′	33′	38′	42′	47′	52′	57′	1°03′	1°09′	1°15′	1°21′	1°28′	1°34′	1°42′	1°49′	1°56′
16°		0	0	1′	1′	2′	3′	5′	7′	9′	11′	14′	17′	20′	23′	28′	32′	36′	40′	45′	50′	55′	1°01′	1°07′	1°13′	1°19′	1°26′	1°33′	1°40′	1°48′	1°55′	2°03′
17°		0	0	1′	1′	2′	4′	6′	8′	10′	12′	15′	18′	21′	25′	29′	33′	38′	43′	48′	53′	58′	1°04′	1°11′	1°17′	1°24′	1°31′	1°38′	1°46′	1°54′	2°02′	2°10′
18°		0	0	1′	1′	2′	4′	6′	8′	10′	12′	16′	19′	22′	26′	31′	35′	40′	44′	50′	55′	1°01′	1°07′	1°14′	1°21′	1°28′	1°36′	1°43′	1°52′	2°00′	2°08′	2°17′
19°		0	0	1′	1′	2′	4′	6′	8′	10′	13′	16′	19′	23′	27′	32′	36′	43′	46′	52′	58′	1°04′	1°11′	1°18′	1°25′	1°32′	1°40′	1°48′	1°57′	2°05′	2°14′	2°24′
20°		0	0	1′	2′	3′	4′	6′	8′	11′	14′	17′	20′	24′	28′	33′	38′	43′	48′	54′	1°00′	1°06′	1°14′	1°21′	1°28′	1°36′	1°45′	1°53′	2°02′	2°11′	2°21′	2°30′

AMERICAN GEOGRAPHICAL SOCIETY

Aerial Surveying on the Coast of Northern Labrador. During July and August Dr. Alexander Forbes of Harvard University carried out an expedition to Labrador in coöperation with Sir Wilfred Grenfell (The Grenfell Northern Labrador Expedition). The expedition was sponsored by the Society, and Mr. O. M. Miller of the Society's School of Surveying was appointed topographer in charge of surveys. The scientific personnel of the expedition also included Mr. Noel E. Odell in charge of the geological work and Mr. Ernst C. Abbe representing the Gray Herbarium.

The coast of northern Labrador is so incompletely surveyed as to render the charts unsatisfactory for mariners, especially in the northernmost 200 miles where gross inaccuracies are to be found in the existing map. In the past the surveyor has been handicapped by the shortness of the season and the distance of the region from convenient bases of operation. The expedition planned to employ several methods of mapping, including one involving the use of oblique aerial photographs worked out by Mr. Miller (see pp. 660–662). Two seaplanes were used for the aerial photography and reconnaissance. A radiogram to the Society dated August 14 announced the successful completion of the field work of the expedition.

Shippee-Johnson Peruvian Expedition. The Shippee-Johnson Peruvian Expedition, which sailed from New York on December 6, 1930, to carry out, with the endorsement of the American Geographical Society, a program of mapping and other photographic work from the air in various parts of Peru, returned on September 7, 1931.

The expedition accomplished even more than had been planned in its tentative program. In addition to the photographing, from elevations of over 25,000 feet, of the deep valley of the Colca River some seventy miles north of Arequipa—the primary object of the expedition—a land party spent two weeks in the valley studying its people, the history of the little-known agricultural communities of the valley floor, their methods of agriculture, etc. The expedition mapped the whole of the Chimú Valley and the ruins of Pachacamac and discovered and photographed, a short distance north of Chimbote, the remains of what appears to be a great defensive wall believed to be a part of the Chimú fortifications against the Inca invaders.

Besides the aerial mapping, hundreds of aerial photographs were taken and a large amount of motion picture film exposed throughout the coastal region of Peru and the western border of the Andes. Several flights from Lima over the western range of the Andes to Huancayo resulted in a series of remarkable photographs of much geological and physiographic interest.

Data from the Arctic Cruise of the "Graf Zeppelin," July, 1931. The Society is in receipt of two original maps showing the course of the *Graf Zeppelin* on its recent flight to Novaya Zemlya and Franz Josef Land and the ice conditions for the Arctic Sea covered by the flight. The Society has also received a set of photographs and a copy of the log of the airship. The prompt receipt of this material was made possible by the thoughtfulness of Mr. Lincoln Ellsworth, who was the Society's representative on the expedition and who was invited by Dr. Eckener to participate in it as Arctic expert for navigation. During the flight Mr. Ellsworth kept in touch with the Society by radiogram direct from the airship and described the course and the principal discoveries. Lieutenant Commander Edward H. Smith, of the United States Coast Guard, represented the American section of the Aeroarctic Society on the flight.

GEOGRAPHICAL RECORD

NORTH AMERICA

Canada's Position in the Mineral Situation of the British Empire. In his presidential address before the Royal Society of Canada Charles Camsell, Deputy Minister of Mines for Canada, reviews Canada's position in the mineral production of the British Empire (*Trans. Royal Soc. of Canada*, Ser. 3, Vol. 25, 1931, Appendix A). The mineral situation of the empire is the strongest in the world, says Dr. Camsell; the only weaknesses are in respect of antimony, mercury, potash, sulphur, and talc—if, in considering petroleum, regard be had to reserves under British control. Canada holds a special place in the situation by reason of the diversity of her resources and the surpluses available for export. The total annual value of the mineral production of the Empire is about $1,865,000,000. Canada's share, 15 per cent, is exceeded by the United Kingdom, which accounts for 47 per cent, and South Africa, 17 per cent. But three-quarters of the former is due to coal, and 90 per cent of the latter to gold and diamonds. Canada has second place in the Empire in gold production; first place in platinum, though there are enormous reserves known to exist in South Africa; first place in nickel—indeed over 90 per cent of the world's requirements are met from the Sudbury ores. Up to a few years ago the Dominion was the only part of the Empire producing asbestos, but valuable deposits in Southern Rhodesia and the Transvaal are now being exploited. By the use of imported ores and the cheap hydro-electric power of the Saguenay, Canada has an output of aluminum—the only source of the metal in the Empire.

In many branches of the mineral industry rapid progress has been made the last few years. Copper resources, in which the Empire's position is "not as strong as we might wish," are more promising with the opening up of new deposits in Northern Rhodesia and new sources in northern Manitoba. Canadian zinc production is growing fast. Lead production in 1930 doubled that of 1929, more than 95 per cent coming from British Columbia and mainly from the Sullivan mine, one of the greatest lead-zinc deposits of the world (compare Philip H. Sheffield: The Trail Metallurgical Plant, *Canadian Geogr. Journ.*, Vol. 3, 1931, pp. 175–197).

Dr. Camsell concludes his address with the emphatic statement that there are large areas of the earth's surface that still remain to be prospected and "not the least important of these lie in northern Canada." The Canadian Geological Survey has recently put out an excellent handbook "Prospecting in Canada" (*Econ. Geol. Ser.*, No. 7, Ottawa, 1930), in which it is stated that "about one-sixth of the total land area of Canada is arable and much of this is already settled or being settled. About 40 per cent is forest-bearing, useful forests extending northward to about latitude 55 degrees in eastern Canada and to the Arctic Circle in the western half. Minerals, on the other hand, are distributed throughout all parts of the country in extraordinary variety and they must constitute the main basis for whatever population and industry develops in the northern half of the country . . . Mining in Canada is quite as permanent an industry as farming or lumbering."

Gaspé and the South Shore of the St. Lawrence. Over two hundred years elapsed between the discovery of Gaspé by Cartier and the beginning of active colonization in a land reputed to be "of mountains, woods, and rocks, the soil of which is wholly sterile and unfruitful." During this period the coast was annually visited by hundreds of Norman and Basque fishing vessels. They arrived in April or May, at the

beginning of the cod-fishing season, and returned to France at the end of November, when the season closed. As early as 1632 Nicolas Denys, the first French Seigneur of eastern Gaspé, had planned the establishment of permanent fishing communities, but these did not materialize until after 1764, when the Jerseyman, Charles Robin, in the rôle of patron of the poor fisherman, developed a monopoly of the fishing and marketing industries. By making payments in goods from the company's stores, he kept the fishermen indebted to him and reduced almost to the position of serfdom. The establishment of the Robin interests was accompanied by an immigration of fishermen from Jersey and Guernsey, who settled along the east coast of Gaspé.

"La pêche, toujours la pêche" was long the theme of all descriptions of the country. The old genre of life in the peninsula and the changes effected since the middle of the last century are discussed by Professor Raoul Blanchard in "Études canadienne: I, La presqu'île de Gaspé (*Rev. de Géogr. Alpine*, Vol. 18, 1930, pp. 5–112). The Robin interests succeeded in fixing for a century the old type of fisher. Fearing that farming might develop as a rival of the fishing industry, the size of farms was limited to about ten acres, an area too small to supply the food needed by the family. The land was cultivated by the women and children since, at the critical periods, the men were occupied with fishing. For the Acadians, however, the sea held little attraction, and the British Loyalists who had settled here retained their agricultural traditions. Isolated farming communities, producing cereals, potatoes, cheese, and butter, developed wherever they settled. The chief purchasers of the agricultural products were the stores operated by the fishing companies, and consequently farmers as well as fishermen were dependent upon these organizations. Butter was the only agricultural product exported.

Large-scale exploitation of the forests began about 1880, and with it came a change of order in Gaspé. Lumbering furnished a supplementary winter occupation to both fishermen and farmers. It assured them of an additional source of income and weakened the control of the fishing companies. The increase in population in Gaspé had been accompanied by a decreasing supply of fish. Some of the fishermen turned to farming, especially along the southern coast, but more sought summer employment in the lumber and pulp mills that sprang up in every village. The proximity of forests and sea particularly favored the development of mills along the north coast. Only at the eastern end of Gaspé does fishing retain its old supremacy.

Gradually isolation, the great factor in the backwardness of Gaspé, is disappearing. The most recent improvement in communications is the magnificent Perron Boulevard, encircling the peninsula, which was completed in 1928. With it has come a new source of income—the tourist industry; and already a new solidarity has developed between the people of the north and south coasts of Gaspé.

But the changing conditions in Gaspé have been accompanied by a serious emigration problem. The winter migration to the interior of the peninsula paved the way for seasonal migration to the forests to the north and west of the St. Lawrence. The irregular operation of the mills in the summer leads to a permanent emigration of men, accompanied by a corresponding exodus of young women. As partial cures for this situation, vigorous coöperation among the farmers and specialization in the production of fruits and vegetables for the late market are suggested. The removal of forests has opened new lands capable of absorbing part of the excess population. The lumber industry is now in a state of reorganization, and the outcome cannot be predicted. But whether Gaspé can meet the changing industrial situation and assimilate her increasing population depends as much upon psychological as upon geographical adjustments.

West of Gaspé along the south shore of the Gulf of St. Lawrence is a region colonized at an earlier date. Active settlement began in the latter part of the seventeenth century at Beaumont, Montmagny, and Cap St. Ignace and gradually moved eastward towards Gaspé, supplying a large proportion of the French Canadian population

of its north coast. This region is described by Professor Raoul Blanchard in "Études canadiennes: II, Le rebord Sud de l'estuaire du Saint-Laurent" (*Rev. de Géogr. Alpine*, Vol. 19, 1931, No. 1, pp. 5–143). Fishing attracted the first settlers, and the long narrow farmsteads fronting upon the river and extending at right angles to it reflect this early interest. A decreasing supply of fish was accompanied by an increase in lumbering; and with the exhaustion of the most accessible forests farming became the most important industry. The traditional cultivation of wheat was discouraged by the competition of the prairie provinces, and the poor yields due to lack of proper agricultural methods, in spite of the fact that the first agricultural school in North America was established at Pocatière in 1859. Today potatoes for the Quebec and Montreal markets form the chief agricultural cash crop. Over 60 per cent of the cultivated land is devoted to forage crops, and dairy products form the largest source of income. Lack of scientific methods results in a low winter yield of milk, and the coöperative butter factories present in all the villages close for a period varying in length from three to six months.

Although the population is scant, the region is overpopulated according to present standards of production. The birth rate, averaging 31.5 per 1000, is high for North America but is accompanied by excessive emigration—30,000 since 1901 and 10,000 since 1921. The retaining of this population is the greatest problem now facing the region. By scientific and intensive methods the area now under cultivation could support three or four times the present population. But this is a comparatively narrow strip lying between the south shore of the St. Lawrence and the northern escarpment of the interior plateau. South of the escarpment is an extensive forested region. Only two routes, the Matapédia Valley and the Temiscouata depression, cross the plateau and connect the St. Lawrence River with the Maritime Provinces. Because of the dense forests and inaccessibility, the population is scant. When a balance is established between the sawmills and the permanent forest resources, the plateau could still support a large agricultural population. LOIS OLSON

The Shortage of Water in the Lower Colorado. Nothing approaching the present seasonal shortage of water has hitherto been recorded in the lower Colorado or observed in the delta. Following the exceptionally moderate summer floods of the past two years and the low-water stage during the earlier months of the present year, it has now brought about conditions in the delta that are extremely serious for the development companies in the newly opened areas in Baja California and also, prospectively, for the irrigation and commercial interests in the Imperial Valley.

Even the maximum discharge at the Yuma gauging station for each of the earlier six months of the present year has hardly reached one half of the recorded mean for the corresponding month during the previous twenty-five years; and during June, which is the normal month for the crest of the summer flood and the maximum discharge for the year, it barely reached one third. July—for which the discharge figures are still incomplete at the time of writing—will show an even more pronounced drop.

So grave has the situation become, in the estimation of the Directors of the Imperial Irrigation District and of the controlling officials operating the lands upon the Mexican side of the border, that a tentative mutual agreement, international in scope, is being formulated at the present time for prorating or rationing the rapidly diminishing supply of water. It is, of course, realized that the effect of the scanty snowfall of the past winter upon the mountains of Wyoming and Colorado is now becoming felt in the lower valley and delta and that no real relief can be expected until the rising temperatures of next spring melt snows that have not yet fallen.

Furthermore, the Imperial Valley, with its fast growing population and prosperous

communities, depends almost entirely for its domestic and municipal as well as for its irrigation water upon the flow that reaches it from the Colorado through the Imperial canal and channel of the Alamo. Some few artesian wells exist in various parts of the basin, principally upon the eastern side; but the flow from them is not very good in quality nor great enough in quantity materially to alter the expected situation of general shortage.

Below the line the problem of the present season is almost entirely an agricultural one, as there are few permanent inhabitants in the region with the exception of the remnants of the Cocopah tribe of Indians, who move their temporary camps along the canals and amongst the cotton fields below Mexicali after the seasonal activities.

Marked changes are taking place in the extent and character of the vegetation of the areas that have been subjected to overflow for several years but which are once more drying. Temperatures have been exceedingly high during the past few weeks, even for the Colorado delta; and, as little water of any sort—good, bad, or indifferent—can be obtained at the present time except along the half-filled canals in the northwestern portion, the undeveloped and still virgin areas are practically void of human beings, and even the wild life of the region seems to have largely succumbed or to have migrated. The situation is quite unprecedented in the writer's forty years of personal observation of the region.

GODFREY SYKES

The Pensacola Terrace, Florida. The lowest and most clearly marked of the Pleistocene terraces of Florida is the subject of an investigation by Frank Leverett (The Pensacola Terrace and Associated Beaches and Bars in Florida, *Florida State Geol. Survey Bull. No. 7*, 1931). Dr. Leverett directed his attention towards two main queries: Has the Pensacola terrace been subjected to differential uplift? What is the probable age of the terrace?

It has been asserted by C. Wythe Cooke that "the Pleistocene coastal terraces along the Atlantic seaboard of the United States are bounded by shorelines that are horizontal south of the glaciated region and that appear to continue unwarped westward along the Gulf coast to Texas" (C. Wythe Cooke: Correlation of Coastal Terraces, *Journ. of Geol.*, Vol. 38, 1930, pp. 577–589; see also *idem:* Pleistocene Seashores, *Journ. Washington Acad. of Sci.*, Vol. 20, 1930, pp. 389–395). However, Dr. Leverett finds that "the altitude of the Pensacola shore-line has a somewhat steady decrease from east to west." He cites an altitude of 43 feet on the east coast; at Tampa Bay opposite, 33 feet; 30 on the meridian of Tallahassee, 25 at Pensacola, 22 at Mobile Bay, 15 at Baton Rouge. Evidence points to the influence of the weight of sediments in the Mississippi delta in the downward tilt of the shore line. The question is raised "whether the interpretation by C. Wythe Cooke that it [the Pensacola terrace] owes its altitude above present sea-level on the Atlantic Coast entirely to a lowering of the sea-level is likely to be sustained." A uniform level along the Atlantic coast might simply mean that the shore line for long distances ran parallel to the isobase of uplift.

The Pensacola shore line exhibits a distinct scarp easily traceable for long stretches. The terrace has very few small independent streams running direct to the coast, and the tributaries to the main streams from the higher land are poorly developed; on much of the surface the drainage lines are so slight that the rainfall is largely disposed in slow-moving widespread currents—features pointing to a comparatively recent age for the terrace. Compared with similar slopes of late Pleistocene lakes in northwestern Ohio that can be dated from Niagara Falls, an age of not over 25,000 years is estimated. A comparative study of the system of bars along the present coast is in harmony with this estimate.

A special interest attaches to the terrace because of the occurrence of human remains in close association with vertebrate and other fossils of extinct species. Dr. Leverett does not enter into the controversy of its bearing on the antiquity of man

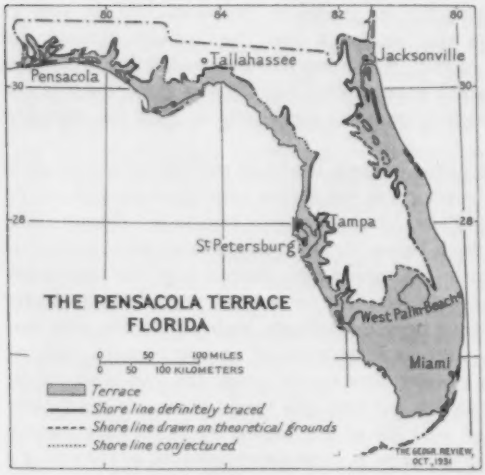

FIG. 1—Sketch map showing the Pensacola terrace based on Dr. Leverett's map. Scale approximately 1 : 12,000,000.

in America that has raged during the past fifteen years, but he cites Dr. Sellards' bibliography on the subject (1919) and brings it up to date. From his study of the topography and drainage relations of the burial sites Dr. Leverett concludes that: "The question of the relation of the coming of man to that of the disappearance of the extinct species of vertebrates seems to resolve itself into a matter of probabilities. If the sea withdrew from the Pensacola terrace within the past 25,000 years, as seems probable from the slight change effected in the shore-line, and the very youthful state of drainage lines across the terrace, the time of occupancy of the terrace by these vertebrates appears not unlikely to have overlapped the peopling of the region by man. The abundance of game in this southern region would seem likely to have led to its early peopling by tribes fond of the chase. As finds increase the relation may be more fully cleared up."

The report is accompanied by a map in color on a scale of approximately 1 : 1,600,000, on which the shore line is distinguished as definitely known, drawn on theoretical grounds, and conjectured. Professor D. W. Johnson, who went over part of the ground with the author, has pointed out the difficulty of determining the exact altitude of the shore line in places, and the author adds a warning that the altitudes should be taken as "tentative and approximate."

The terrace is "of more than academic interest," and at Dr. Leverett's suggestion Roland M. Harper adds a brief chapter on "Some Economic Features of the Pensacola Terrace in Florida." Dr. Harper's statistical data show the terrace to be rather better populated and to outrank the rest of the state in wealth and culture. For the most part this condition is a development of the last fifty years. When Florida became connected with the north by railroad the state had a chance to capitalize its climate and ocean beaches in the winter resort industry. Many tourists became residents, and the Pensacola terrace has gained a progressive and cosmopolitan population. Agriculturally the terrace was behind the fertile uplands of the state until the introduction of drainage ditches and commercial fertilizers permitted the entry on a specialized type of farming. In 1920 the value of crops per acre on the terrace was nearly four times that of the upland.

"Without the very extensive beaches which the State of Florida possesses it is doubtful whether the warm winter climate alone would have attracted nearly as many winter residents and tourists from the north." This great asset of the Pensacola terrace is described by James H. C. Martens (Beaches of Florida, *Twenty-first—Twenty-second Ann. Rept. Florida Geol. Survey*, 1928–1930, Tallahassee, 1931, pp. 67–119). He concludes his general and regional descriptions with a note on the preservation of the beaches. There are still some long stretches of unspoiled beach "along the back of which no one lives," which it would be well for the state, counties, and municipalities to acquire and reserve for the use of the public "in somewhere nearly its natural condition."

SOUTH AMERICA

The Exploration of El Reventador, Eastern Ecuador. The ascent of El Reventador, eastern Ecuador, is announced by General Luis Telmo Paz y Miño. The following account is condensed from his official report (La Exploración al Reventador, *Publ. Ministeria de Educación Pública*, Quito, 1931).

As far as can be ascertained the first suggestion of the possible existence of a volcano hitherto unknown to science far to the east of the well known cones that surmount the plateau of the Andes of Ecuador was contained in a letter written by Señor Nicolas G. Martinez, Acting Director of the National Meteorological Observatory, published in the Quito newspaper *El Comercio* in July, 1922. Señor Martinez had made an ascent of Cotopaxi in an attempt to determine whether the peculiar bluish clouds that had obscured the horizon from Imbabura to Chimborazo during the preceding February and March might possibly have been caused by exhalations of gas from that volcano. He was certain from his examination of Cotopaxi that this could not have been the case and suggested that the source of the clouds was to be found in a volcano in the Oriente region near the headwaters of the Coca River, which he described as unknown to science but long well known to rubber gatherers, who called it "El Reventador."

In February, 1926, a second letter from Señor Martinez was published in *El Comercio*, in which he called attention to a recent rain of ashes of unknown origin in the interandean region and submitted such information as he had been able to gather concerning the mysterious "El Reventador." He stated that, although the volcano in the Oriente mentioned by Humboldt, Villavicencio, Wolf, and other nineteenth-century authorities on the geography of Ecuador had been generally accepted as being Sumaco, Jiménez de la Espada and G. M. Dyott, the only two scientific observers who had ascended Sumaco (the former in 1860 and the latter in 1925), both found it in a state of absolute tranquillity. It seemed probable, therefore, that it was another volcano to which these geographers referred. Dyott told of having seen from the summit of Sumaco an isolated volcano far to the north.

In 1927 Mr. Joseph H. Sinclair arrived in Quito to continue the survey work he had carried out in the Oriente region in 1921. He became deeply interested in the possibility of locating a new volcano in the Oriente, decided to make it the objective of his expedition, and on January 15, 1928, set out from Quito with a small party (Joseph H. Sinclair: In the Land of Cinnamon: A Journey in Eastern Ecuador, *Geogr. Rev.*, Vol. 19, 1929, pp. 201–217). His route took him by way of the Papallacta Trail to Baeza, by way of Archidona to the Napo River, up this stream to its confluence with the Coca, and thence back westward by the Coca and its tributaries.

After a journey of considerable difficulty Mr. Sinclair arrived at an eminence near the right bank of what he believed to be a continuation of the main stream of the Coca. According to his calculations he was then closely approaching the site of the volcano. While examining the country from this hill in order to determine the best route for continuing, his guides suddenly called out "El Volcan," and, looking southwestward, he saw through a momentary rift in the mists an isolated mass of jagged peaks which he calculated to be about 1622 meters above the sea. A deep canyon separated the party from this mountain mass, and it proved impracticable to go farther. Once more just as the party reached the river on the return trip the mists cleared again and revealed a brief glimpse of the mountain. Unfortunately, on neither occasion was there time to photograph the mountain; but its position and altitude were determined with reference to a traverse that had been carried in from the position at the confluence of the Coca and Napo rivers determined by Mr. Sinclair in 1921. From the brief glimpses had of it, the mountain appeared to be quite unrelated to the general physiography of the surrounding region, and it seemed reasonable to believe it was "El Reventador."

The National Geodetic and Geophysical Commission of Ecuador felt that an expedition to the volcano could make a most valuable contribution to the knowledge of what is perhaps the least-known section of the country. A request for financial assistance in carrying out such an expedition was addressed to the Minister of War and Marine with the result that, on December 22, 1930, a commission consisting of General Paz y Miño, Jonas Guerrero, and Cristobal Bonijaz set out from Quito. Señor Bonijaz had already made an unsuccessful attempt to reach the volcano by a northern route in March of that year.

From Quito to Baeza the commission followed the route taken by Mr. Sinclair but from there set out northeastward to the Hacienda Las Pampas whose proprietor, Señor Aurelio Dāvila G., had already cut a trail through to the Rio Malo and installed cableways over the Oyacachi and Salado rivers. From Las Pampas the volcanic cone that was the object of the journey was seen rising in a direction N. 21° E. of the hacienda.

The advance as far as the Rio Malo (January 1) was rapid and, thanks to the efforts of Señor Dāvila, without serious difficulty. Considerable trouble was experienced in crossing the Malo, a large swift-flowing stream with high, vertical walls; and thence progress was slow because of the necessity of cutting the trail in advance of the main party. Strangely enough, also, whereas between Las Pampas and the Rio Malo the route was crossed by numerous streams of various sizes, water, at least in the vicinity of suitable camping places, was not easily found. By January 4 a point was reached where the steepness of the ascent suggested the neighborhood of the volcano and open spaces in the forest were covered with a layer of ash.

At an altitude of 3200 meters the forest gave way to a jungle of plants of the genus *Gunnera*, and this in turn, to a wide, open space covered with a thick coating of ash. A base camp was established 200 meters below the volcano and 1000 meters westwards.

On the morning of January 5 the ascent was accomplished, the highest point of the crater rim being reached in less than two hours. Here a flag was set up, and at its foot was buried a lead tube giving the date and time of the ascent. The crater was quiet, but evidence of its recent eruption was to be seen in the thick covering of ash all the way up from the camp. The edge of the crater was followed for nearly an hour or until heavy clouds made it impossible to continue farther. Next day some of the members of the party again made the ascent and were able to see the whole of the crater.

According to the published report the position of the volcano is approximately 0° 04′ 00″ S. and 77° 39′ 30″ W., and its altitude 3485 meters, making it 0° 04′ 20″ north and 0° 10′ 00″ west of the peak located by Sinclair and 1863 meters higher. The members of the expedition express themselves as certain that the cone reached by them was the one they observed from the Hacienda Las Pampas and that it is the volcano known to the inhabitants of the Oriente as El Reventador, whose eruptions in January, 1926, were seen from Quito. They believe that Sinclair did not see the volcano itself but one of the many lower peaks that they themselves observed to the east of the volcano rising from the broad mountain mass on which it stands; and in order to avoid confusion they suggest that, on future maps of the region, the name El Reventador be moved to the new location and that the 1622-meter peak seen by Sinclair be named for its discoverer.

Ecuadorean scientists are, however, by no means so certain that the crater reached by the expedition is the true source of the violent eruptions noted in Quito in 1843, 1894, 1898, 1912, and 1926. Nicolas Martinez, to whom much of the interest in the location of the volcano is due, has been at the forefront of the controversy and has stated categorically in a letter written to General Paz y Miño on April 13, 1931, and made public the next day in *El Comercio*, that he is sure from the description of the crater discovered by the expedition that it is not the volcano whose violent

eruptions were seen from Quito in 1926. Martinez explains that whereas he expected to hear of the forests surrounding the crater destroyed and covered with fragments of bombs and other evidence of recent eruptions, he gets a description of an absolutely dead volcano—apparently dead for centuries—with the exterior of the cone, the interior walls, and even the bottom of the crater covered with a veritable forest of *Gunnera*, and no trace of the exhalations of fumes or of the odor characteristic of volcanoes in repose after recent eruptions. Certainly, as has been frequently commented during the controversy, there is much more suggestion of a volcano in recent eruption in the jagged peaks rising above the surrounding forest described by Sinclair.

Geographers and cartographers will regret that the published report of the expedition contains no indication of what survey methods were used on the journey, how the numerous astronomical positions given in the report, including that of the crater itself, were determined, and how the map of the region which accompanies the report was constructed.

Recent Explorations in Southern Venezuela. In a paper recently delivered before the College of Engineers of Venezuela Dr. Alfredo Jahn, the well known Venezuelan engineer and geologist, reports the results of explorations in the Venezuelan Guiana carried out in 1930 at his suggestion by Felix Cardona, a young Spanish engineer (A. Jahn: Una importante contribución a la hidrografia de la Guayana Venezolana, *Revista Colegio de Ingenieros de Venezuela*, Vol. 8, 1931, pp. 655–668).

Cardona set out to survey, by means of traverses tied to positions located by astronomical observations in connection with radio time signals, the Caura and Paragua rivers and the Orinoco from its source to the Atures and Maipures rapids. The hostility of the Indians prevented him from carrying his traverse of the Orinoco beyond the entrance to the Casiquiare Canal, but he did map in considerable detail the Orinoco between the Casiquiare Canal and the Maipures Rapids, the entire course of the Ventuari, the upper Caura from its source to the mouth of the Erebato in latitude 6° 13′ 2″ S., the whole course of the Erebato, and the Paragua from its mouth in the Caroní to about latitude 5° S. The maps compiled by Dr. Jahn from Cardona's surveys and published with the report on the scale of 1 : 750,000 are an important contribution to the cartography of this hitherto little-known section of Venezuela. Unfortunately, except for altitudes along the rivers determined by barometric observations the maps give little indication of the character of the topography.

The Venezuelan Guiana—the section of southern Venezuela bounded by the Orinoco River on the west and north and by Brazil and British Guiana on the south and east—has been described as one of the largest and most interesting of all the unexplored areas in South America. Because of the difficulty of entering it, either from the Orinoco or by way of Brazil or British Guiana, few scientific explorers have penetrated into it for any considerable distance. Schomburgk on his expedition of 1838–1839 entered its southwest corner from Brazil by way of the Uraricoera River; and Koch-Grünberg in 1912, entering also from the Uraricoera River, mapped the sources of the Caura and Ventuari rivers. In 1930 Desmond Holdridge, an archeological explorer for the Brooklyn Museum, reached the upper Caroní by way of Mt. Roraima and explored it for some distance (see Desmond Holdridge: Notes on an Exploratory Journey in Southeastern Venezuela, *Geogr. Rev.*, July, 1931, pp. 373–378). The only survey in the region of the upper Orinoco, except for traverses of the river itself by Chaffanjon, Rice, and Dickey, is that of the Cerro Duida region carried on in 1928 by the Tyler-Duida Expedition (see G. H. H. Tate and C. B. Hitchcock: The Cerro Duida Region of Venezuela, *Geogr. Rev.*, Vol. 20, 1930, pp. 31–52). Attention is called to the fact that only at the sources of the Caura River did the Cardona expedition enter the so-called Pacaraima region to which

the American Museum of Natural History, the New York Botanical Garden, and the American Geographical Society are planning a joint expedition equipped with airplanes for transport and survey work (see H. E. Anthony, H. A. Gleason, and R. R. Platt: The Pacaraima-Venezuela Expedition, *Geogr. Rev.*, Vol. 21, 1931, pp. 353–362).

The Chile-Peru Boundary Survey. The survey and demarcation of the Chile-Peru boundary, the final act in the settlement of the long-standing Tacna-Arica dispute, have been completed and a detailed account of the work published by the Chilean government in a three-volume report entitled "Memoria sobre los límites entre Chile y Perú de acuerdo con el tratado del 3 de Junio 1929 presentada al Ministerio de Relaciones Exteriores de Chile por Enrique Brieba, Miembro Representante de Chile en la Comisión Mixta de Límites entre Chile y Perú" (Santiago, 1931).

The work of surveying and marking with eight permanent monuments the 165 kilometers of boundary from the Bolivian border to the Pacific Ocean was carried out with exemplary efficiency and dispatch. Seven months were spent on the field work and a little more than ten months on the office work including the mathematical calculations and the drafting of a large number of plans and maps. The total cost, borne by the Chilean government in accordance with the terms of the Treaty of June 3, 1929, was 412,125 Chilean pesos, nearly 8000 pesos less than the amount allocated for the work. A Mixed Commission consisting of one Chilean and one Peruvian member had full charge of the plans for and the execution of the work in the field. The various subcommissions working in the field were expressly instructed to carry out only the orders of the Mixed Commission and were required to refer to it all problems arising in the field, however insignificant, in order that the members of the Mixed Commission might be directly responsible to their respective governments for every item in the location of the line.

It will be recalled that, in the treaty, the greater part of the boundary was described as a line starting from a point to be called Concordia, ten kilometers north of the Arica-La Paz Railway bridge over the Lluta River and continuing to the Pacific Ocean and to the Bolivian border parallel to and ten kilometers from the Arica-La Paz Railway; the only exceptions being the short section of the line between Concordia and the Pacific, the course of the line around the Tacora sulphur district which was assigned to Chile, and the Laguna Blanca section. (See note in *Geographical Review*, Vol. 19, 1929, pp. 501–503.) Plane-table surveys were made to facilitate the locating of the line in the Tacora and Laguna Blanca sections. The section of the line parallel to the railway was by no means as easy of location as was originally supposed. Not only was there no point found at which the boundary zone was visible from the railway, but it was found that there were no surveys of the railway sufficiently accurate to be used as a basis for the establishing of the ten-kilometer line. It was necessary in the first instance, therefore, to make a rigid triangulation of a strip of territory covering the course of the railway at the ten-kilometer zone and including a precise survey of the railway itself. Then by constructing on the map plotted for these surveys ten-kilometer arcs from a large number of points on the railway line a tentative location for the boundary was established which was used as a basis for the final location of the line. The course of the line in the Concordia, Laguna Blanca, and Tacora sections was decided by diplomatic conversations on the basis of maps and suggestions furnished by the Mixed Commission.

AFRICA

The Tsetse Fly in the Sudan and in Tanganyika Territory. Until about 1890 sleeping sickness (trypanosomiasis) was confined to western equatorial Africa. Its eastward spread is to be attributed to "the pacification of Africa, the abolition of

tribal warfare, the opening up of trade routes, and general freer intercommunication." In the Uganda epidemic of the early years of this century the population of the lake district is said to have been cut from 250,000 to 50,000. Major G. K. Maurice, in *Sudan Notes and Records* (Vol. 13, 1930, pp. 211–245), gives a vivid account of the successful combat waged by British administrative and medical officials against the disease in the Anglo-Egyptian Sudan, 1911–1928, and particularly in the Bahr al-Ghazal province. In the latter area a settlement was established where natives were brought for treatment. Here, between 1918 and 1928, 3630 persons were treated, of whom 1551 died and 928 were discharged as cured. More important, however, was the preventive work. *Glossina palpalis*, the species of tsetse fly that predominates in the Sudan, is seldom found more than a few hundred yards from water. It was thus possible to circumvent the disease by removing the population from fly-infested localities. This task was accomplished in a few years by a mere handful of British officials. The region was mapped, trails and roads were built, and tribesmen who had hitherto lived widely scattered through the forest were concentrated in villages on the roads and out of reach of the dread river banks. "In the course of the campaign . . . the habits of the natives were transformed . . . Superstition waned, agriculture prospered. The task of extirpating a disease had profoundly affected the life of a people."

Sleeping sickness may be dealt with in particular areas by such methods. There are, however, other species of disease-carrying tsetse fly, such as *Glossina morsitans*, which do not cling to the swamps and borders of rivers and lakes but stray far from water (a map showing the distribution of *Glossina palpalis* and *Glossina morsitans* accompanies Wilhelm Frantzen: Die geographische Verbreitung und wirtschaftsgeographische Bedeutung der Tsetse-Fliege, *Matériaux pour l'Étude des Calamités*, 4th Year, 1927–1928, pp. 293–338; see also the reports on tuberculosis and sleeping sickness in Equatorial Africa published by the Health Organization of the League of Nations, 1923–1927). In the belts where *Glossina morsitans* prevails it is not feasible, as in the Sudan, to remove the population from the danger zones. Indeed, in the last analysis, sleeping sickness will probably be eradicated from African soil only with the elimination of the tsetse fly itself.

Before this can be brought about much more must be learned about this fly. In other words, the solution of the problem of sleeping sickness will depend largely upon progress in the observational and experimental study of the ecology of its carrier. A start has been made in this direction, and methods of research are being perfected (J. F. V. Phillips: The Application of Ecological Research Methods to the Tsetse (*Glossina* spp.) Problem in Tanganyika Territory: A Preliminary Account, *Ecology*, Vol. 11, 1930, pp. 712–733). Comprehensive investigation of the ecology of the tsetse fly, moreover, may be expected to yield results of great value to students in allied fields. For example, Phillips has contributed to the *Journal of Ecology*, Vol. 18, 1930, pp. 193–234, a paper on "Some Important Vegetation Communities in the Central Province of Tanganyika Territory." This is distinctively a study in plant ecology and plant geography: in it the tsetse fly is barely mentioned. The writer, however, states that a primary purpose of his paper is to furnish a working knowledge of plant communities essential to research officers and administrative officers concerned with the problem of sleeping sickness.

Vegetational Regions of Tanganyika Territory. An outline of the vegetational regions of Tanganyika Territory is given by J. F. V. Phillips in the *Transactions of the Royal Society of South Africa* (Vol. 19, 1931, pp. 363–372). Classification is "in accordance with the several local climates," and six major divisions are recognized. The coast and coastal hinterland includes the coastal zone proper from the sea to a distance of 10 to 20 miles inland, marked by a high humidity. It exhibits such distinctive formations as mangrove swamp forests and, on coral and dune land,

the evergreen coastal scrub, gnarled, stunted, impenetrable, with canopy "frequently appearing as an inclined plane—the result of wind-action." The coastal hinterland with lower humidity and less actual rainfall extends to the foothills of the mountain buttresses of the central plateau. The elevation ranges from 300 to 2000 feet. Upon the alluvial soils palm communities and open acacia woodland are important. Other savana types occur on residual soils, and upon sites protected from fire is a dense semi-deciduous thicket. Apart from its more tropical character and greater luxuriance the vegetation of the coastal hinterland is generally similar in physiognomy to that of the great central plateau. The plateau has a mean elevation of 4000 feet and is moderately warm and dry (compare the rainfall map in Tanganyika Territory Geological Survey Annual Report for 1929). There is much variety in the vegetational types, but the deciduous scrub seems to be the climax vegetation when fire does not interfere with succession. The eastern slopes of the great ranges bordering the central plateau and of the Kilimanjaro-Meru region from 1600 to 6000 feet, with high humidity and heavy rainfall, are clothed with tropical evergreen or "rain" forest, classed as lower level and upper level forest. On the lower slopes of western and southwestern Kilimanjaro and on Mt. Meru is a drier type of forest.

The higher parts of the bordering ranges and the upland west of the Eastern Rift at altitudes from 6000 to 10,000 feet, with high humidity, fairly heavy rainfall, and frequent mists, constitute the subalpine zone. On the upper portion of Kilimanjaro-Meru, Rungwe, and other of the highest peaks this gives place to an alpine zone from 10,000 to 15,000 feet with dense heath thickets and alpine grassland. "This is a truly attractive and remarkable region—in it are found European herbs and grasses, large woody representatives of genera that in Europe are delicate herbs, and striking, often times fantastic, forms of plant life." The vegetation of the equatorial basin of Lake Victoria is distinguished by the occurrence of a number of west African species and forms.

In this paper and the papers by Dr. Phillips mentioned in the preceding note frequent reference is made to the effects of fire on the vegetation. This important subject is one to which the author has paid considerable attention. Elsewhere he says "During several years' observation in Eastern Africa I have come to the conclusion that fire is a factor of the greatest importance in the life of biotic communities" (Fire: Its Influence on Biotic Communities and Physical Factors in South and East Africa, *South African Journ. of Sci.*, Vol. 27, 1930, pp. 352–367). He does not think that the effect of firing is altogether harmful, as some writers have asserted, believing that "*controlled* firing is a *useful* and *oftentimes necessary* agent in veld management and in Tsetse-fly control."

Some New Maps of Southern Rhodesia. The first number of the "Official Year Book of the Colony of Southern Rhodesia" was issued in 1924, coincidently with the inauguration of responsible government; the second number (1930) now makes a welcome appearance. The volume is greatly expanded—from 329 to 862 pages; and the maps (scale 1 : 3,000,000), one of the most useful features of the first number, have been thoroughly revised. The "Orographical" map of 1924, almost diagrammatic in character, gives place to a "Contour" map providing a much more real picture of the country. One may remark, for instance, the way in which the great 1500-to-2000-foot escarpment to the Zambezi Valley on the north is brought out and the mountainous area on the eastern border with Inyangeni reaching 8250 feet. The geological and mineral maps also show refinement, and there are no inconsiderable changes in the "Normal Rainfall Map" for the period 1898–1926. In the text one may note the table of distribution of normal rainfall and of the lower limit of reliable rainfall. "The temperature of the wet bulb thermometer is usually considered the best criterion of the habitability of an area." Griffith Taylor's "relative comfort" scale (from "Australian Meteorology") is quoted,

and on this basis it is pointed out that about one-third of the country is unsuitable for close settlement of whites, roughly the area under 3000 feet, half in the Zambezi Valley, at present inaccessible and unoccupied, and the rest in the Limpopo and Sabi valleys, utilized for stock raising.

The orographical, geological, and rainfall maps are reproduced in an article by J. S. Henkel ("Types of Vegetation in Southern Rhodesia," *Proc. Rhodesia Sci. Assn.*, Vol. 30, 1930–1931, pp. 1–23). With a map of mean annual temperature they are supplementary to a "Provisional Map of Vegetation Types in Southern Rhodesia" on a scale of 1 : 2,000,000. The prime division is into closed forest, open forest, and grassland. Closed forest occupies a comparatively small area on the humid eastern border and also occurs as fringing forest along the streams. It is mostly evergreen and in general appearance is similar to the mist-belt closed forest of the Union of South Africa.

The open forest is properly described as tree veld. It is usually deciduous or semi-deciduous and is divided into eight main associations here distinguished by the native name of a particularly prominent tree, except in the case of the well known thorn veld of acacias. The classification is by altitude and ranges from the *Muhatja* type on the higher part of the main plateau in the east to the *Mopani* type, the distribution of which on the map seems to approximate roughly to the 3000-foot contour. In general the upper limits of the *Mopani* zone and of the palm, *Hyphaena ventricosa*, mark the "frost line."

On the high and middle veld frosts occur from May to September and may be severe. In September of 1930, for instance, much injury was done by frost in the southeast. Grassland characterizes the *vleis* of the middle veld in valleys where cold air collects. It also occupies level water-logged areas of the plateau whence trees are excluded by the extremes of water supply. Much of the area of the great norite dike that crosses the country from north to south is grass-covered because of the shallowness of the soil. Mountain grassland forms dense swards surrounding the closed forests and extends above their upper limit, the boundaries usually being sharply defined. All the grasslands are annually or periodically burned over. "Perhaps of equal importance with fire are the termites." In the middle veld termite mounds attain a diameter of 60 feet and an altitude of 20 feet. Affording a means of escape from the periodic inundations of the rainy season, they are characterized by a special flora and often carry very large and ancient trees (compare also J. Burtt Davy: The Forest Vegetation of South Central Tropical Africa, *Empire Forestry Journ.*, Vol. 10, 1931, pp. 73–85).

ASIA

The Variability of Rainfall in India. In 1918 Griffith Taylor published a map of reliability of rainfall in Australia (The Australian Environment (Especially as Controlled by Rainfall), *Commonwealth of Australia Advisory Council of Science and Industry Memoir No. 1*, 1918). Isopleths show the percentage variation from the normal amount. In the interior of the continent, with rainfall averaging 5 to 10 inches for the most part, variability is highest, rising to 40 to 50 per cent. A map of "relative frequency of annual precipitation less than 85 per cent of the average," included in the U. S. Atlas of Agriculture, shows highest frequency—50 per cent—about the lower Colorado and the Imperial Valley. In other studies of variability made in the Transvaal (F. E. Plummer: A Preliminary Investigation into the Variability of the Rainfall of the Transvaal, *South African Geogr. Journ.*, Vol. 9, 1926, pp. 5–20) and Southern Rhodesia (C. L. Robertson: The Variability of Rhodesian Rainfall, *South African Journ. of Sci.*, Vol. 24, 1927, pp. 102–109) the relationship is less clear or more complicated, but the drier areas in both instances show comparatively high variability.

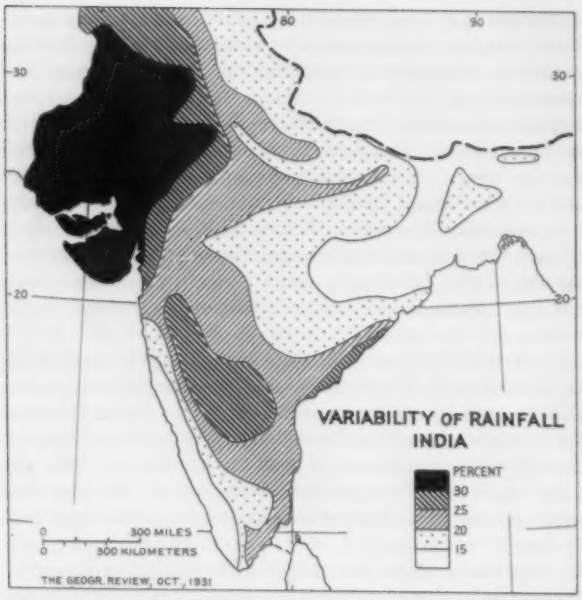

FIG. 1—The variability of rainfall in India, based on the map by A. V. Williamson and K. G. T. Clark. Scale approximately 1:37,500,000.

An excellent illustration of the generalization that the lower the average rainfall, the higher the variability, is afforded by India, as A. V. Williamson and K. G. T. Clark demonstrate in their study "The Variability of the Annual Rainfall of India" (*Quart. Journ. Royal Meteorol. Soc.*, Vol. 57, 1931, pp. 43–56). Variability, "the most outstanding characteristic of the rainfall of India," is calculated on the basis of percentage departures negative and positive from the normal rainfall that has occurred in 50 per cent of the period 1890–1923. The purpose of the formula used is to eliminate the effect of "phenomenally abnormal" occurrences and indicate general trends. A comparison of Williamson and Clark's India with Biel's map of the variability of rainfall over the world (Erwin Biel: Die Veränderlichkeit der Jahressumme des Niederschlags auf der Erde, *Geogr. Jahresber. aus Österreich*, Vol. 14–15, 1929, Pl. 21) shows a generally close agreement. Biel made his calculations on the basis of mean departures from the normal (1881-1920) expressed in percentages. The main discrepancy between the maps is in the Deccan, where Biel shows a variability of only 15 to 20 per cent. This is explained by the marginal situation of his stations, which do not express conditions in "the dry and precarious tract which makes up the core of Peninsular India."

Figure 1, reproducing Williamson and Clark's map in simplified form, might almost be the inverse of the mean annual rainfall map. Naushedro in Sind with a mean rainfall of 5 inches has a variability of 53 per cent; Cawnpore with 34 inches has 20 per cent, and Calcutta with 65 inches has 11 per cent variability. A second generalization is formulated—that reliability is less when rainfall is concentrated than when it is well distributed in time. Sometimes the two generalizations may operate in opposite directions. Surat with 40 inches of rain falling in 46.5 days has a variability of 31 per cent; Coimbatore with 22 inches falling in 43.9 days has a variability of only 14 per cent.

The authors make application of their variability study in the preparation of a map of the rainfall regions of India (*Geography*, Vol. 16, 1931, pp. 98–108).

A Japanese Regional Study. A regional study of a small area in central Honshiu by Katsue Misawa, published in the *Geographical Review of Japan* (Vol. 5, Nos. 9 and 10, 1929) has been translated by Shigeru Matsuki. The paper is a synthetical study. Seventeen outstanding features of the landscape have been studied and mapped. By a comparison of these the landscape has been reconstructed and subdivided. The region chosen is the southwest quadrant of the slope of Yatsugatake

Volcano, 9500 feet, on the southeastern border of the Suwa Basin region (described by Glen T. Trewartha in the *Geogr. Rev.*, Vol. 20, 1930, pp. 224–244). It constitutes a topographic unit of 180 square kilometers separated from the adjacent slopes by rivers on the north and east and by a fault line on the southwest. "Since ancient times this has been treated as a separate unit." The underlying rock is a stratiform agglomerate much of which has been covered by more recently formed lava flows, scoria, loam, and mud flows.

The 26,000 inhabitants of the region live in villages at an altitude lower than 4000 feet (1200 meters). Above this are the higher mountain slopes whose grasslands supply green manure and whose forests form the reserves of wood of the district.

The lower, outer slopes of Yatsugatake are almost equally divided between the cultivation of rice and mulberry. The slope is comparatively uniform and is traversed by streams that have exposed some of the underlying rock and left ridges of loam. The climate of the region is governed by the altitude. Lacking definite temperature data, the author has substituted the date of the blooming of the early flowering cherry. So great is the force of the winds that growing hedges serving as windbreaks are a dominant feature of the landscape; the higher the altitude the taller the hedges. It is interesting to note that during a recent famine it was the village of Haneba, which is without windbreaks, that suffered most. The rivers spread out from the mountain like the ribs of a fan. Their cold waters first stand in *nurumes*, or shallow reservoirs, to warm before being used for irrigating rice. In the southeast, where springs with their colder water are more extensively used for irrigation, the yield of rice is proportionally lower.

The maps showing the cultural aspects of the landscape divide the lower slopes into two distinct subdivisions. The northern region, in which there is the greater per cent of cultivated land and a denser population, corresponds to a wider distribution of volcanic ash soil. Here the larger amount of purchased manure is used, the greater number of people are engaged in spring sericulture, there is more manufacture of autumn silkworm-egg cards, and fewer acres are required to produce a bag of unhulled rice. The manufacture of handsaws is a supplementary occupation of the type encouraged by a long winter in an agricultural region. In the south the exposures of the less fertile loam are greater, the rice fields are less extensive, and the yields are smaller.

THE OCEANS

Circulation within the Depths of the Pacific. The water within the depths of the Pacific Ocean is of a remarkably uniform character. From a depth of 1000 fathoms to the bottom the waters within this huge basin have a salinity of from 34.6 to 34.8 and a temperature close to 2° C. As a result, charts showing the salinity and temperature distribution within the Pacific are characterized by nearly horizontal isohalines and isotherms. This is in marked contrast to conditions within the depths of the Atlantic and Indian Oceans, in which both isohalines and isotherms show characteristic downward bends in progressing from south to north. These differences in the conditions within the depths of the oceans clearly must be traced to differences in circulation. Before 1928, however, accurate observations within the depths of the Pacific were so few as to preclude any definite conclusions as to the character of the circulation in the depths in that basin.

In an article on "The Origin of the Deep-Water of the Pacific Ocean as Indicated by the Oceanographic Work of the Carnegie" (*Gerlands Beiträge zur Geophysik*, Vol. 29, 1931, pp. 95–105), Dr. H. U. Sverdrup attempts to trace the circulation within the depths of the Pacific on the basis of the observations made by the late Captain J. P. Ault and his collaborators on the seventh cruise of the *Carnegie* during the years 1928–1929. While these observations are not sufficient to permit final

conclusions, the data now at hand indicate that the deep water of the Pacific originates in the eastern part of the Indian Antarctic Ocean. From here it enters the Pacific through the opening south of New Zealand as a slow current. This finds corroboration in the fact that the waters in the depths of the Pacific have a relatively low oxygen content which indicates that they must have traveled a considerable distance as deep-sea currents.

H. A. MARMER

Types of Seas. In an article under the title of "Meerestypen" (*Meteorol. Zeitschr.*, Vol. 47, 1930, pp. 402–411) E. Markus proposes a five-fold classification of the surface regions of the sea: namely cold tropic, warm tropic, cold polar, cold temperate, and warm temperate. This classification is based on the concept of nature complexes (naturkomplexe), a concept elaborated by the author in detail elsewhere (*Sitzungsber. Naturf.-Gesell. bei der Univ. Dorpat*, Vol. 32, 1925). A nature-complex is defined by Markus as the totality of causally connected features and phenomena that are localized in a given region. An oceanic nature complex is thus an area of the sea characterized by distinctive local features that arise from a group of mutually interacting hydrographic, climatic, biologic, and other phenomena.

On investigating the relation between precipitation and the temperature anomalies of the surface waters of the sea, Markus finds that regions of little rainfall are characterized by negative temperature anomalies, while regions of heavy rainfall are characterized by positive temperature anomalies. With both temperature and temperature anomalies of the surface waters as criteria, the different oceanic regions are readily grouped under the above five types of seas. Each of these types is distinguished by definitely localized climatic and oceanographic features. Thus, cold tropic seas are characterized by negative temperature anomalies, high temperatures of both air and water, little precipitation, moderate temperature fluctuations, and cold currents. The lands bordering such regions are, in consequence, generally arid steppes or deserts. Warm tropic seas, on the other hand, while possessing, in common with the cold tropic seas, high air and water temperatures, differ from the latter in being characterized by positive temperature anomalies of the surface waters and by warm currents and heavy precipitation. The lands bordering warm tropic seas are therefore regions of tropical rain forests and of tropical and subtropical vegetation generally.

Markus discusses the distinctive climatic and oceanographic features of various oceanic regions that illustrate the different types of seas and outlines these regions on a world map. He notes, however, that these cannot be sharply delimited from one another, since any two regions merge into each other through a transition zone. And he directs attention to the fact that these different types of seas correspond to ideal nature complexes in that each of these types results from features and phenomena that are causally interrelated.

H. A. MARMER

The Tidal Problem of Euripus. The so-called tidal problem of Euripus relates to the complicated tidal movements within the strait of Euripus, the narrow channel separating the island of Euboea from the mainland of Greece. The current through this strait has a considerable velocity, up to 8½ miles an hour. During the greater part of the month the movement of the current takes place in the normal manner of two ebbs and two floods a day. At the times of the moon's first and third quarters, however, the movement becomes irregular, changing from flood to ebb and back again to flood as many as twelve or more times a day. The peculiar character of the tidal movement here has been known since ancient times. Indeed, according to tradition, Aristotle met his death here by throwing himself into the waters of the strait in despair at his inability to explain these movements.

In a paper entitled "Le problème de la marée de l'Euripe" (*Annales Observatoire*

Natl. d'Athènes, Vol. 11, 1930), Prof. Démétrius Eginitis studies the question in detail. He finds that although the strait is only 130 feet in length, the tides at the two ends differ both in time and in range, being in fact independent tides. As a result, the tidal movement through the strait is of a hydraulic nature, the strait acting merely as a channel through which the water flows from the body having, temporarily, the higher level to the one having the lower level. For the greater part of the month the rise and fall of the tide in the bodies of water at each end of the strait is large enough to maintain a regular flow. At the time of the moon's quadratures, however, when the tidal forces of sun and moon are opposed, the rise and fall of the tide is small and hence seiches—oscillations of the water due to nontidal causes—bring about frequent changes in the relative elevations of the two bodies of water and hence frequent and irregular changes in the movement of the water through the strait.

As a result of his study Eginitis concludes that each of the bodies of water at the ends of the strait oscillates independently but that the tides in each are derived from the eastern Mediterranean. This would explain the difference of 1¼ hours in the time of tide in the two bodies. He concludes, too, that a rereading of Aristotle's text relative to the matter proves him to have given a correct explanation of the irregular character of the current here.

H. A. MARMER

WORLD AS A WHOLE AND LARGER PARTS

French Aerial Surveys in Morocco and Syria. French penetration of the wild and rough hinterlands of Morocco and Syria, where native opposition takes the form of spasmodic guerrilla warfare, has been handicapped by the lack of accurate maps. However, in Morocco the Topographic Bureau succeeded in providing a reconnaissance map of an area almost as large as France within the short space of seventeen years, an accomplishment made possible by the aid of aerial photography since 1917. The method of constructing the reconnaissance maps from the aerial mosaic is set forth by Commandant Gendre and Captain Delaye in the *Revue de Géographie Marocaine* (March, 1930, pp. 3–12).

An interesting instance of the use of aerial photographs in Morocco is given by Captain Pennès and Lieutenant Spillmann, the one attached to the aviation branch of the army, the other to the Native Affairs Division. The surveys of the upper Draa made by the former and interpreted by the latter present an intimate picture of an area (of 62,000 square kilometers), practically unpenetrated by Europeans. The report, "Les pays inaccessibles du Haut Draa" (*Rev. de Géographie Marocaine*, Vol. 8, 1929, Nos. 1–2, 63 pp. and atlas) is in effect a regional geography uniquely illustrated by aerial mosaics companioned by sketch maps showing the culture of the area. The distribution of palms throughout the region is but one of the interesting results of this study. A further account, "Description géographique de la Haute Vallée du Draa," is given by Lieutenant Spillmann in the June, 1930, number of the *Revue de Géographie Marocaine*.

In Syria a single flight made on May 10, 1927, in an army machine permitted a view of the whole volcanic area of Leja and Safa (Damascus Plain) and made it possible to trace the lines of faulting and tentatively to place this area in its relation to the African Rift Valley and Taurus systems. Père Poidebard contributes his notes made immediately after the flight to *La Géographie* (Vol. 52, 1929; pp. 1–17) and concludes by saying: "Seen from 1800 meters the depression situated between the Jebel Druze and the desert appeared marked by major eruptive lines SSE to NNW, the principal lines of fault, lines of cleavage paralleling the direction of the great lines of the Red Sea and Persian Gulf." The oblique and vertical views have been used advantageously in revising existing maps of the area. Louis Dubertret has also employed them as a basis for his paper, "Étude des régions volcaniques du Haouran,

du Djebel Druze et du Diret et Touloul (Syrie)," in the *Revue de Géographie Physique et de Géologie Dynamique* (Vol. 2, 1929, pp. 275–321.)

PHYSICAL GEOGRAPHY

Vegetation as an Indicator of Surface Formations and Structure. The extraordinary sensitiveness of the aerial camera to shades of difference in the surface cover of the earth—rocks, soils, vegetation—gives great scope to mapping from the air What can be accomplished is well illustrated in the archeological field by O. G. S. Crawford, who has made excellent use of crop differences in his aerial photographs of archeological sites. "Growing vegetation reacts differently to different constituents in the soil, and this produces tone-contrasts. In this class fall ancient remains which have been levelled and are no longer visible on the ground" (O. G. S. Crawford: Air-Photography for Archaeologists, *Ordnance Survey Professional Papers, No. 12* (N. S.), 1929). Air photography is likewise increasing the field of geological mapping, and here, too, vegetation furnishes useful indications. As a result of the aerial survey in Northern Rhodesia Mr. Bourne deduced "that the distribution of the vegetational types and sub-types, considered in conjunction with soil colour and the form of the drainage system, indicates: (a) changes in geological formation, (b) the stratification of certain formations, (c) the outcrop of certain strata, and (d) the general direction of strike in stratified rocks" (R. Bourne: Aerial Survey in Relation to the Economic Development of New Countries, with Special Reference to an Investigation Carried Out in Northern Rhodesia, *Oxford Forestry Memoirs No. 9*, 1928, p. 27).

How the vegetation gives a key to the underlying rocks is illustrated by Robert H. Cuyler from central Texas (R. H. Cuyler: Vegetation as an Indicator of Geologic Formations, *Bull. Amer. Assn. of Petroleum Geologists*, Vol. 15, 1931, pp. 67–78). A close investigation was made of the relation between woody plant species and the geological formation in the Cretaceous of central Texas, Austin quadrangle. The vegetation helps in the discrimination of two formations so closely similar as not to be readily distinguished in all cases by the usual means (Travis Peak and Glen Rose formations). The one supports an association of Spanish oak and mountain cedar, while the other has few Spanish oaks and an abundance of the mountain cedar with much sumac, which is rare on the former. Texas oak appears on the Walnut and Comanche Peak formations, but the foliage of the former with a richer soil is a darker green than that on the poorer Comanche Peak soil. The Edwards formation is characterized by dense thickets, "oak shinneries" of the mountain scrub oak, which seldom grows on the other formations of the region. On a bed of gravels and clay in the massive limestone of this formation the oak is replaced by mesquite. "This bed may thus be recognized for miles. From a distance it appears as a light green band between two dark green masses." The succeeding formation (Georgetown) of soft nodular limestones supports the mountain cedar and skunk bush, "the latter easily distinguishable because it grows to the exclusion of almost everything else." The vegetation of the other formations is equally distinctive.

The closeness with which plant changes conform to formation changes is illustrated by the recognition of a fault through the abrupt change from cedars (Georgetown) to scrubby oak (Edwards). On the Gulf coastal plain faults have been mapped by the water-loving rattlebush. Water forced up the fault plane will support the plant, thus revealing a structure of which there may be no other surface indication.

HUMAN GEOGRAPHY

Studies in the Origin of Cultivated Plants. In "The Rôle of Central Asia in the Origin of Cultivated Plants" (*Bull. Applied Botany, of Genetics and Plant Breeding*, Vol. 26, Leningrad, 1931, pp. 1–44; in Russian with English summary) Professor

N. I. Vavilov presents another chapter of the interesting work he is prosecuting so energetically as Director of the Institute of Plant Industry at Leningrad. It relates to field work undertaken by him conjointly with Drs. M. G. Popov and V. V. Dubiansky in Sinkiang embracing the territory between Kashgar and Urumchi.

Previous investigations had established the exceptional importance of the region enclosed by the southwestern Himalaya and the southeastern Hindu Kush as a center of origin of cultivated plants (compare "Agricultural Afghanistan," *Geogr. Rev.*, Vol. 19, 1929, p. 681). Central Asia, on the contrary, shows no features pointing to independent beginnings of agriculture. The number of field crops in the ancient agricultural regions of Chinese Turkestan is very limited even where natural conditions are favorable. Many wild relatives of cultivated plants so common in southwestern Asia are absent. The conspicuous lack of varietal diversity points to the influence of the Himalaya, Pamir, and Tian-Shan as barriers and "filters" to plant migration. For instance there are only 10 varieties of soft wheat in Central Asia as against 60 in Afghanistan. Recessive forms, characteristic of peripheral plant areas, are abundant.

The crop plants of Central Asia come mainly from southwestern Asia and "Asia Media" (Fergana, etc.)—wheat, barley, chickpea, flax, alfalfa, cotton, such spices as coriander and dill, various *Cucurbita*, grapes, apricot, pomegranate, almond, fig; from India comes the Indian cucumber; from China and the east, millet, Italian millet, soy bean, opium poppy, buckwheat, the rice grown in eastern Sinkiang, the Japanese plum. Much truck garden stuff comes from the Chinese and also gardening technique, while many of the gardeners are Dungans, a Sinicized people of Central Asia, Chinese, or Koreans.

The autochthonous crops of Central Asia are few. Hemp is one of the most important, and specially interesting are the apples of Alma-Ata (the former Verny), Kazakstan, whose new name means "apple-town." Here is a whole series of links from the wild, inedible apple to cultivated ones; "some of the apple trees positively offer themselves for cultivation."

The work of the Russian Institute of Plant Industry has also been extended to the New World, "which is of special interest to us by its industrial crops" (N. I. Vavilov: Mexico and Central America as the Principal Center of Origin of Cultivated Plants of the New World, *Bull. Applied Botany, of Genetics and Plant Breeding*, Vol. 26, Leningrad, 1931, pp. 135–199). For instance, for the extension of cotton cultivation in the U. S. S. R. early varieties are needed, and such may be found in the highlands of southern Mexico and Guatemala. The *guayule* is the most interesting rubber plant for the U. S. S. R. It is now in cultivation in Turkmenistan and Azerbaijan.

Agriculture in pre-Columbian America originated independently. It arose on the basis of a peculiar wild flora under conditions quite different from those of the Old World. As E. D. Merrill has recently put it, at "the dawn of recorded history, every important basic food plant now grown was already in cultivation somewhere in the world; many of these were widely disseminated in either the eastern or the western hemisphere, *but none was common to both regions*" (The Phytogeography of Cultivated Plants in Relation to Assumed Pre-Columbian Eurasian-American Contacts, *Amer. Anthropologist*, Vol. 33, 1931, pp. 375–382). "As far as we know," says Vavilov, "only one plant of the Old World of secondary importance had reached America before Columbus, and was grown already by farmers of the ancient civilizations of Central and of South America. This is the bottle-gourd."

Botanically Mexico and Central America are very imperfectly known, yet even so their overwhelming importance in species as compared with the rest of North America is established, and this is true also for the cultivated plants. To an area comprising not more than one-twentieth of the continent "a rather considerable part of the plant resources of the world owes its origin"—corn, upland cottons, squashes, cacao, henequen are among the list. Richest of all in endemic species

of cultivated plants and in their varietal diversity is southern Mexico. This geographical localization is in sympathy with the diversity of ecological conditions and is a further illustration of the fact established for the Old World that the principal centers of origin of cultivated plants are "chiefly peculiar to the subtropical and tropical mountain zones."

Unlike some of the Asiatic and African centers of origin, in Mexico and Central America the wild links of many of the cultivated plants are present, and all phases of introduction into cultivation can be traced. The people of these regions still make much use of wild plants.

In opposition to general opinion Professor Vavilov believes that primeval agriculture was, as a rule, non-irrigated. He compares the irrigated agriculture of Egypt and Mesopotamia, showing a poor varietal diversity of cultivated plants, with adjoining agricultural mountain countries from which they have obviously borrowed. "Rice grown in China and Japan under conditions of irrigation, is a crop of secondary origin, in spite of its great economical importance for these countries at the present time. This becomes quite obvious in comparing the varietal diversity of the Indian rice with that of China and Japan."

Studies of the Rural Habitation. Slovakia generally speaking is a country of nucleated settlement. However, in the western Beskids and the more southerly part of the watershed between Moravia and Slovakia (Little White Carpathians) and in certain other smaller areas is a dispersed type of settlement—small hamlets and isolated houses, "Kopanice." Pierre Deffontaines, who describes the condition in a paper entitled "Un type de peuplement dispersé en Slovaquie," asks whence it arises: is it because of a different mode of life or difference in racial origins? Both, seemingly. The dispersed population is dominantly pastoral; many of its customs and costumes are "Vlach," there are many Vlach place names in these areas, and many Vlach terms are in circulation, especially such as apply to pastoral life, in which the Slovak tongue is deficient. "Vlach" is a vague designation of broad application. Sometimes it is used as a synonym for those peoples of southeastern Europe whose speech is of Latin derivation. In Slovakia it is applied to immigrants from the south and east, pastoral mountain peoples doubtless of varied ethnic origin. Extended historical researches are needed really to elucidate the question.

"The Vlach migrations have given a common stamp to pastoral life in the Tatra and the entire chain of the Carpathians" says Zofja Holub-Pacewiczowa in a study of "The Habitation and Pastoral Migrations in the Tatra and the Sub-Tatric Region" (Osadnictwo pasterskie i wedrówki w Tatrach i na Podtatrzu, *Prace Komisji Geograficznej*, No. 1, Cracow, 1931). Here is presented a highly detailed account of the evolution of a primitive mode of life now rapidly declining. The results of the author's minute researches are summarized on a large-scale map in color (1 : 75,000) defining crop land, pastures, forests, waste land, various types of chalets classed according to regional character, function, and seasonal occupation, kinds of roads, boundaries, and the like; and in a number of smaller maps.

The paper first mentioned, that of M. Deffontaines, is a contribution to the "Second Report of the Commission on Types of Rural Habitation" of the International Geographical Union (1930). Among other papers included in this report are one by Martin Vahl on the distribution of the population of Denmark, with maps in color (scale approximately 1 : 700,000 though no scale nor projection appears) showing the density of the farming population and the percentage of the population industrial; a continuation of her studies in western France and the Channel Islands by Miss S. Harris; and papers on the rural habitation in certain provinces of Egypt by Jean Lozach and Georges Hug. The two last-named contributors have carried their Egyptian studies to completion in "L'Habitat rural en Égypte," published in 1930 by the Royal Geographical Society of Egypt and described by Albert De-

mangeon in his preface as "a model study." It gives an intimate picture of the village and the house of the *fellah* placed in the setting of the rural economy of the country. It is based in the first instance on the results of a questionnaire (in French, English, and Arabic) from which 4000 responses were obtained. A historical perspective permits one to see the changes in progress in types of habitation. The commonest and the ancient type is the crowded village, adapted to the old communal life and work, to protection from the Nile floods, and defense against marauders. The development of irrigation, the new order and security, new kinds of crops, the creation of private property, and the coming of large capitalistic enterprises are favoring dispersion. Maps in color (1 : 500,000) show general distribution of habitation types and of house materials. Sectional maps on larger scales illustrate typical distributions, and there are many excellent photographs.

Strongly agglomerated settlement is well exemplified in the *Sahel*, the Mediterranean border of the north African steppes on the east coast of Tunisia. Here in the hinterland of Susa and Mahdia are some 50 villages many of which have more than 5000 inhabitants and several more than 10,000—the densest population in Tunisia. This compact sedentary population of olive growers is in profound contrast to the bare monotonous steppes to the west and the new sparsely peopled plantations of Sfax to the south. Olive cultivation goes back to Roman days, but the population then was disseminated: the change to agglomeration came about with the advance of nomadism—insecurity threatening from the steppe (Jean Despois: Essai sur l'habitat rural du Sahel tunisien, *Ann. de Géogr.*, Vol. 40, 1931, pp. 259–274).

A further response to the questionnaire launched by the Commission on the Rural Habitation appears in "L'Habitat rural au Maroc" (*Rev. de Géogr. Marocaine*, Vol. 15, 1931, pp. 69–152), as a series of local studies preceded by a paper on the general problem by Dr. Pons.

A unique form of habitation is seen in "Les villages ronds du Razès," described by L. Josserand in the *Revue Géographique des Pyrénées et du Sud-Ouest* (Vol. 2, 1931, pp. 5–21). The villages are really round: the striking aerial views show concentric rings of houses round a central core, and variants of the generally circular arrangement are exhibited in the black-and-white village plans. The country—a part of the Aude basin below Limoux—is one of concentrated settlement, but the villages are generally small, most of them having from 200 to 400 people. Agriculture is diversified—meadows in the valley bottoms, grains on the slopes and the clayey terraces, vineyards on the gravelly hills. In pre-feudal days the population apparently was dispersed. The need of defense presumably was in part responsible for concentration. The form of rural economy with the land held in small scattered parcels seems to explain the numerous small-sized agglomerations.

GEOGRAPHICAL REVIEWS

The Turin Map of 1523

Alberto Magnaghi. **Il planisfero del 1523 della Biblioteca del Re in Torino: La prima carta del mondo costruita dopo il viaggio di Magellano: unica copia conosciuta di carta generale ad uso dei piloti dell'epoca delle grandi scoperte.** 92 pp.; maps, index. Otto Lange, Florence, 1929. $8.00. 14 x 10 inches.

"Il Planisfero del 1523 della Biblioteca del Re in Torino," by Alberto Magnaghi, is a valuable contribution to the cartographical record of the Spanish and Portuguese discoveries. The map is not dated, but from internal evidence Magnaghi concludes that it was made subsequent to the return of Juan Sebastian de Elcano (the spelling is that of M. F. de Navarrete) in September, 1522, and prior to the conclusion of the Congress of Badajoz in April, 1524. As it would necessarily require some time to coördinate the information brought back by de Elcano with that obtained previously from Spanish and Portuguese discoveries, Magnaghi thinks the map was made in 1523. Because of the presence of certain Italicisms it is determined that the cartographer was an Italian. Then, by the process of elimination, it is concluded that the cartographer was Giovanni Vespucci. The size of the map and the absence of decoration suggest that the map was prepared for the use of pilots rather than court circles.

The copious references to authorities add greatly to the value of Magnaghi's work. There is a separate identification of each of the names on the coast of the Americas and in the Pacific. These names are accompanied with various data. Sometimes there is a comparison with the names given by contemporary cartographers. Occasionally there is an interpretation of the name or comments on the discovery, the discoverer, and the earliest historians. Magnaghi devotes special attention to that part of the South American coast and the Pacific regions particularly associated with the discoveries of Magellan. This is appropriate because the map is undoubtedly most important as a record of the Magellan expedition, and to this Magnaghi devotes the more important part of his work. Magnaghi grants that Magellan may have planned, as Juan Dias de Solis certainly had planned, to trace the west coast of South America north to the Isthmus of Panama, where the new Spanish settlements were located, and from thence to seek the Moluccas along the equator.

Magellan is supposed to have laid a course to the northwest from about latitude 32° S. This is the traditional view. The present writer believes otherwise. In his study "The Columbus and Magellan Concepts of South American Geography" (Philadelphia, 1931) he shows that South America was regarded by Magellan before his voyage as a part of Asia, and in that case the Pacific Ocean and the Mar del Sur were parts of the Indian Ocean. By many the Spice Islands were supposed to lie only a short distance west of Panama. This fact places the plans for the Magellan expedition in a new light. A careful comparison of the accounts of Magellan's voyage as given by the Genoese pilot, the anonymous Portuguese, Pigafetta, Maximilian of Transylvania, Peter Martyr, João de Barros, Oviedo, Las Casas, López de Gómara, and Herrera with the log of Francisco Albo raises so many doubts and involves so many discrepancies that the customarily accepted route must be sharply questioned. The writer hopes soon to show that Magellan probably crossed the equator not far west of Panama and thence sailed westward near the tenth parallel of north latitude. Clipperton Island may have been his San Pablo or Tiburones Island.

This planisfero occupies an important place in the sixteenth century cartographical record. Before Magellan's voyage there was uncertainty as to the size of the earth. Columbus based his enterprise on the theory that the length of a terrestrial degree at the equator was 56⅔ Italian nautical miles. This had the consequence of placing the east coast of Asia at about 265 degrees east of the Canaries, or 95 degrees west thereof. It also placed Cipango at about 62 degrees, or 750 leagues measured along the 28th parallel, west of the Canaries. The Columbian theory came into conflict with the Ptolemaic theory as interpreted by Martin Behaim and Waldseemüller. As a result, the earliest mappemondes show various types as they endeavor to reconcile these two theories. The writer has arranged these maps in eight types, "World Map of Francesco Roselli" (Philadelphia, 1928), showing various relations of the Spanish discoveries to Marco Polo's Asia. They range from the Bartholomew Columbus maplets, where the Spanish discoveries are placed on the coast of Asia, to the Waldseemüller 1507 map where is shown a completed eastern Asia about 45 degrees west of the Atlantic coast of a peninsula resembling Florida.

Meanwhile the Portuguese had conducted their own explorations to the east. At the Congress of Badajoz it is known that the Portuguese had abandoned the Ptolemaic conceptions about the size of the earth. They accepted an equatorial degree of 70 miles, each mile slightly longer than the Italian nautical mile—a value very near the correct one. This conception placed the east coast of Asia about 50 degrees west of where the Behaim-Waldseemüller Ptolemists put it, while Columbus placed the same region about 45 degrees to the east of the place where the Behaim-Waldseemüller Ptolemists put it. The Magellan voyage rendered untenable the Columbus concept concerning the size of the earth.

We have at least one map, which is presumed earlier than the Magellan voyage, that places a vast sea between Panama and Malacca, according to the Portuguese theory. This is the map called the Munich-Portuguese and dated, by E. L. Stevenson, about 1518. The Turin map of 1523, is, however, the first such map based on actual discovery. The Schöner 1523, also based on information derived from the Magellan voyage, makes an interesting comparison with the Turin map (compare the reviewer's article "The Lost Globe Gores of Johann Schöner, 1523–1524; A Review," *Geogr. Rev.*, Vol. 17, 1927, pp. 476–480). The Schöner map definitely connects America and Asia, a relation not denied by the Turin map. The Turin is in some respects quite similar in concept to the Cabot map of 1544. It is noticeable, however, that it omits the Cabot and Corte Real discoveries shown on the earlier Cantino and Canerio maps. It also fails to connect Florida with the rest of the Gulf of Mexico coast, like the Munich-Portuguese and Peter Martyr maps.

It may be pointed out that Magnaghi's identification of the "Rio del esprito santo" (the spelling conforms with that of each particular reference) with the Mississippi follows the mistake of Kohl, Rye, and Winsor. It is only necessary to point out that the "Rio del esprito santo" empties into a considerable bay, while the Mississippi enters the Gulf of Mexico via a delta that renders its greatness inconspicuous. Both Oviedo in his "Historia General y Natural de las Indias" (Vol. 1, Bk. 17, Ch. 26, p. 562) and Gómara in his "Historia General de las Indias" (Vol. 1, Ch. 12) state explicitly that the "Rio del Spiritu Sancto" enters into a large bay, and it is so shown on the Garay and the Cortes maps, both contemporary with the Turin planisphere. Comparison of the "Rio del esprito santo," as shown on the 1523 planisfero, with modern maps would seem to indicate that it probably entered Mobile, Pensacola, or Apalachicola Bay. La Salle's failure to find the river from the gulf side and the subsequent trouble in regard to identification by the English and Bienville render it difficult to believe that the Mississippi had been discovered by the Spaniards before 1523. Walter B. Scaife in "America, Its Geographical History 1492–1892" (pp. 139–176) seems to have adequately disposed of the supposed identity of the "Rio del Espiritu Sancto" with the Mississippi.

This is not the first time that this map has been reproduced. E. L. Stevenson included it in his collection of "Maps Illustrating Early Discovery and Exploration in America" (1903). He also published a very small reproduction of it in the *Bulletin of the American Geographical Society* (Vol. 39, 1907, p. 204). However, the scarcity and the great price of the first reproduction and the inadequacy of the second make Magnaghi's reproduction none the less desirable. His plan of publishing the map in sections with a reduced-scale key map presents the planisphere in sufficient detail for ready use. The map plates are most excellently done. The whole work, indeed, is highly creditable to Signor Magnaghi.

GEORGE E. NUNN

NEW LIGHT ON TUDOR GEOGRAPHY

E. G. R. TAYLOR. **Tudor Geography 1485–1583.** ix and 290 pp.; maps, diagrs., ills., bibliogr., index. Methuen & Co., London, 1930. 15s. 9 x 6 inches.

Professor Beazley's classic "Dawn of Modern Geography" has had no sequel on any comparable scale. The chances are that it will not have and that the later history of the science will be explored country by country rather than for Europe as a whole. Professor Taylor has now begun that exploration for England. She has written the history down to the appearance of Hakluyt and promises a sequel for the age of Hakluyt and Purchas.

The book is authoritative. Surveying the geographical literature of a century, the geographer explains many matters which had puzzled the mere historian. She has made a special contribution by bringing in the mathematicians. And with much skill in historical research she has frequently gone behind the documents and resolved moot points in maritime history. The work is good history as well as geography.

The first two chapters make a rapid survey of the literature. The first new find is a manuscript "Cosmographia" of perhaps 1510. If the date is correct (the author does not justify it), this anonymous work contains the earliest description in English of the new lands. The mid-century works of the mathematicians Recorde, Digges, and Dee are then given new importance. The providing of British material for Ortelius and Mercator in the sixties is emphasized, as also the local map making, the popularizing of knowledge of navigation, and the outbreak of voyage literature.

The Book of Robert Thorne, which Hakluyt printed as an expansionist tract, is now first explained. The second part of the Book, the address to the King, is now dated 1530, and it is tentatively assigned to Roger Barlow, who had sailed with Sebastian Cabot to the Southwest. Barlow is also made the author of a new discovery, a manuscript "Geographie" of 1541. This work is announced for publication by the Hakluyt Society, and one hopes that the earlier "Cosmographia" will accompany it. Both Barlow and Thorne are shown to have drawn upon Enciso's "Suma" of 1519, and Barlow's work is tentatively linked with the 1541 plan for a northern voyage. These activities of the pair fall into place as the main exploring projects of the reign of Henry VIII.

Another chapter discusses the French pilots in England in the fifteen-forties. Nicolas de Nicolai, with his rutter of Scotland and England, and Jean Rotz, with his differential quadrant, are the more important persons.

John Dee's geographical career is now first adequately set forth, to the extent of three chapters. His relations with the continental geographers are ably described, and this account, together with the list of the books he owned, makes an authoritative record of the "importing" of the new science into England. His part in the first northeast expedition, that which "discovered" Russia in 1553, is made explicit. Indeed, the "intellectual" preparation for that voyage is for the first time explained, and the project is convincingly linked with the African voyages of the time and with a northern project as well. This new synthesis is probably the main contribution of the book to maritime history.

The relations of Dee and others to Frobisher, Drake, and John Davis are further described. Not so much is new here; but new relationships are brought out, and the geographical issues are presented. The idea of Dee as the first modern geographer in England is a contribution.

The final chapter on practical surveying and navigation gives an able account of the new instruments (forms of the plane table and the theodolite) devised on the continent and of their being taken up by Leonard Digges and William Bourne.

The basis of this history is the list of geographical and kindred works in Appendix I. This list may be taken as final. An equally striking catalogue is that of the books in contemporary libraries, those of John Dee the scientist, Sir Thomas Smith the savant, Lord Lumley the amateur, and Samuel Purchas. I think this catalogue was worth a little more discussion.

In fact, I find that Professor Taylor's pace throughout the work is a little too rapid. New geographers have been brought forward, and new light has been thrown on the mobilizing of geographers for oversea voyages, resulting in a new historical perspective leading up to Hakluyt. But this perspective is not yet quite clear. The volume is not so much "Tudor Geography" as it is "New Light on Tudor Geography." It is not complete in itself. The reader has to hold fast to the knowledge he has already derived from Harrisse and Williamson in order to understand the new contribution. One hopes that the completed work will be broader and less hurried—that it will, in sum, take on something of the sweep of Beazley.

GEORGE B. PARKS

ISLAM IN THE LIGHT OF HISTORY AND GEOGRAPHY

E. F. GAUTIER. **Moeurs et coutumes des Musulmans.** 307 pp.; map, diagrs., ills. (Collection d'études, de documents et de témoignages pour servir à l'histoire de notre temps.) Payot, Paris, 1931. 25 fr. 9 x 5¼ inches.

"Manners and Customs of the Moslems"—such an innocent title! One expects the usual account of bazaars and harems, mosques and prayers, Ramadan and the Mecca pilgrimage—of all the familiar things that have been described a thousand times. To be sure, these things enter into Professor Gautier's picture, but there is far more besides. He seeks not merely to describe but to explain and interpret. He ranges up the stream of history, even to the Pleistocene, and he essays a glimpse into the future. The Egyptologist, the Arabicist, the classical or medieval scholar may raise critical eyebrows; but the author himself is the first to acknowledge that his work is open to criticism, "particularly in our epoch of specialized erudition." "Apparently," he adds, "it would have been better not to have written this book. In other words, it would have been better to have given up trying to understand Islam. This would have been the most discreet thing to do and what all the world has done." The reviewer is glad, however, that Professor Gautier preferred to stray from the path of discretion.

To many, even to scholars, the rise of Islam and the blossoming of Saracen civilization have seemed sudden, astonishing, inexplicable—creations, as it were, out of nothing. The Moslem theologians and historians have naturally believed that Islam was the work of Allah and that all that went before was of little account. Modern Arabicists have been prone to accept this doctrine, influenced by the Arabic writings to which they have confined their attention, perhaps too closely.

Gautier maintains that the elements entering into the Moslem faith, the details of the Islamic ritual, the daily life of the Moslem people, their concepts of family, state, and nation, their science, technology, and architecture are all deeply rooted in the geographical circumstances and earlier history of the Orient. Surely this is a thesis that the historically minded reader can hardly fail to accept. Human institutions do not spring abruptly out of nothing.

Even in the sweeping suddenness of the Arabs' military success there was nothing astonishing or abnormal. The Arab conquests were due in part to the application of a military technique adapted to the open steppes of the Near East and Africa —the use of cavalry. The Romans never thoroughly mastered this technique, but Cyrus and Alexander had employed it before the Arabs with equally spectacular results, and in later days it made possible the onrush of Jenghis Khan and many another Oriental conqueror.

The only parts of Spain and of Sicily where Islam struck root for any considerable time were those regions where Punic civilization had once flourished. "The rupture between Islam and Christianity came exactly along the ancient line of cleavage between the Punic Orient and the Occident." The Moslem looks upon this as pure coincidence: to him the conquest was God's act, and it is "evidently absurd to suppose that God would be stopped by historical memories." Gautier sees more than mere coincidence. He pictures the Moslem conquest as "the recovery of the ancient Oriental domain," a recovery that could hardly have been achieved had not there been involved something deeper and more lasting than brute force.

What really happened, as he interprets it, was that the East awoke and reasserted itself after twelve centuries of Occidental domination. The Hellenistic civilization imposed on the Levant by Alexander the Great and his successors was essentially Western. Rome had laid a veneer of Latin culture over the "Punic Orient" of North Africa, southern Spain, and western Sicily. But if Occidental manners and customs and modes of thought prevailed for more than a millennium in the cities of these regions, the great masses of the people, the peasants and nomad tribes, were never wholly Hellenized or Latinized.

Judaism and Christianity in their early stages had met profound spiritual needs, needs distinctively Oriental; but during the Hellenistic age they became alienated from their Eastern setting. Christianity was Westernized in dogma and ritual after its adoption by Greeks and Romans; and Titus, in destroying Jerusalem, "put an end to the old and created the new form of Judaism," the Judaism of a homeless nation of outcasts scattered throughout the basin of the Mediterranean. The Orient had "kept neither Judaism nor Christianity to itself as its own and in forms adapted to its social and individual requirements." The soil was ready for the coming of Islam.

The situation of the Orient in the Hellenistic age was not unlike that of the present. "Once before the East has been dead, buried under a deep layer of Occidental customs. Yet it was destined to revive, brilliantly, full of youth and new life. . . . With Islam the Orient not only conquered the whole of its former political domain but regained in the domain of civilization its ancient intellectual preëminence. There is a precedent here of immense practical importance. We are justified in supposing that history is beginning over again. That which has been will be." Perhaps. Gautier's concluding remarks are more restrained: "We cannot project the past with precision into the future; that would be too convenient. No one, however, will go so far as to suppose that there is no connection between what has gone and what is to come."

Central Europe

Emmanuel de Martonne. **Europe Centrale, Part I: Généralités—Allemagne.** 379 pp.; maps, diagrs., ills. (Géographie Universelle, Vol. 4.) Librairie Armand Colin, Paris, 1930. 110 fr. 11½ x 8 inches.

All geographers welcome the appearance of new volumes in this unexcelled series. Volume 4, "Central Europe," by Professor de Martonne, embraces Germany, Poland, Switzerland, Austria, Hungary, Czechoslovakia, and Rumania. The first part, here presented, deals with the "General Controls" of Central Europe (pp. 1–130), and the second part with Germany in particular.

The climate of Central Europe is illustrated by three isothermal maps (reduced to sea level), followed by a good rainfall map in which the heavy rains of Dalmatia are clearly brought out. It would have been well to have given an actual annual isothermal map. The tracks of the cyclones are shown on several charts, but it is not quite clear what season each represents. Good descriptions are given of the climatic conditions in Poland, the Danube and Rhine basins, the Alps, and Bavaria. Two beautiful photographs of clouds on Lake Thun and of the Weisshorn close the chapter on climate.

In illustration of relief there is a large colored map of the salient geological features, for the Alps, to use the author's words, are the "ruin of a tectonic edifice." A clear account of Pliocene *nappes* and folds follows. The period of glacial erosion is illustrated by splendid photographs of cirques and moraines. Discussion of the Carpathians, which in most features are of less interest than the Alps, follows. In the former the flysch is very common, but calcareous masses are relatively rare, and the forms are generally softer and have less character. In the following chapter on the "Hercynian World," as throughout the book, the importance of understanding the geological "skeleton" is stressed. There follows a discussion of the plains of the region classified into German-Polish, Danubian, and the Sub-Alpine Couloir. Under "The Waters" special treatment is given to the Rhine, Elbe, Vistula, and Danube, and the author uses his "index of run-off" in an interesting map. Two full-page maps show the various types of vegetation and of soils. Prairies occupy the tectonic basins while fir and oak clothe the upland slopes.

An interesting chapter deals with the peopling of Central Europe. The author rightly warns against confusing *nation* with *race*. In his opinion the idea of nationality is of recent growth. Language is perhaps the main factor in nationality, but ideals of liberty play a large part. A discussion of the plebiscite areas illustrates his arguments.

Two-thirds of the book deals with Germany. The author begins by a discussion of the divisions and population. A good colored map emphasizes the density of the people around Essen and Leipzig. Of somewhat less importance are the groups along the Rhine and near Berlin and Magdeburg. Only near the Frisian region is the population less than 25 to the square kilometer.

Regional studies begin with the southern Rhineland. In the morphological maps *structure* is emphasized rather than contours, and this is the case throughout the book. At the end of this regional study, as in later chapters, special attention is given to two or three of the chief cities. The next chapter describes the northern Rhineland with its ancient schistose massive pierced by the Rhine Gorge. A beautiful photograph of one of the famous "incised meanders" of the Moselle is included.

There is a full account of the Ruhr region with its varieties of coal seams aggregating 79 meters. These beds have been slightly folded but are much less affected than the coal of the Franco-Belgian field. Special attention is given to the means of transport in this region, and a full-page map indicates the great variety of industries. The growth of Duisberg from 1894 to 1927 is represented on two large maps.

It is shown that in structure Swabia resembles the Paris Basin, with its alternating resistant cuestas and weak vales. But in Swabia the rivers largely flow away from the center, so that the Danube has lost many tributaries to the Neckar. A clear block diagram illustrates this region, and a similar diagram is used in dealing with the next section, on Franconia. The wealth of fluvio-glacial features in the Bavarian region is clearly set forth in the next section.

Chapter 16 deals with Saxony and bordering districts. The industries are defined on a large map, and one is struck with their diversity in the Chemnitz area. The author then passes to Thuringia, where the salient characters of the Harz Plateau and of the dome of the Vogelsberg are clearly set forth. The modest ranges near the Weser recall the structure of the Appalachians.

The last regional section describes the Great Northern Plain. In the portion west of the Elbe soil differences seem to be the main control; much is heathland (Geest) associated with vast deposits of peat. The eastern part of the plain is of a different character, for the land is covered by great moraines and is now dotted with innumerable small lakes. An adequate discussion is also given of the Baltic shore with its remarkable lagoons and *Nehrungen*, or sandbars. Chapter 19 is devoted to the ports and chief towns of the great plain, such as Leipzig, Breslau, Hamburg, Bremen, and Berlin. Each of these cities is illustrated by maps and aerial photographs.

The last two chapters deal with the general economic life and commerce of Germany. Various maps show that peasant holdings are more numerous in the west and large estates in the northeast. Other maps and cartograms illustrate the distribution of agricultural products, mines, and industries. The remarkable railway net of Germany is described, and a particularly interesting map is given of the inland waterways. Here we can see at a glance their relative importance. The Rhine (up to Mainz) and the Elbe are outstanding, but the Emden-Duisberg route is almost as important as the latter. The famous link from the Rhine to the Danube (via Wurzburg and Ratisbon) is of little importance. A discussion of imports and exports closes the book.

The reviewer has long felt that the geography of the future must be written by scientists who not only thoroughly understand the geology and morphology of a country but are willing to devote considerable space in their books to this aspect of the subject. When, as in the present instance, they also give numerous block diagrams—which save pages of description—and aerial photographs the reviewer feels that little more can be asked for! Professor de Martonne's fine work should long stand as the authoritative volume on this portion of Europe.

GRIFFITH TAYLOR

RHINE NAVIGATION

J. ROUCH. **La navigation du Rhin.** Maps, diagrs. *Bull. Soc. d'Encour. pour l'Industrie Nationale*, Vol. 129, 1930, pp. 551–604.

In all that has been written on Rhine navigation this study is notable as a complete and concise account. Accompanied by maps, charts, and up-to-date statistics it covers every phase of the subject.

The physical characteristics of the river are treated from the point of view of their influence on navigation. The climate of the valley, the depth and conditions of the channel, the regularity of the flow, and the character of the territory through which the river passes are considered from the Alps to the sea. Discussing the climate of the valley the author points out that it traverses three zones; the first of which he calls Swiss climate, the second the gentle climate of the middle Rhine, and the third the North Sea climate of the low countries. Maximum rainfall occurs during the summer throughout most of the valley, but there are considerable variations in amount from place to place. Stress is placed upon the wide variations in temperature and rainfall that occur from year to year.

Seasonal variations in the average flow are considered in great detail for various sections of the stream. Melting ice and snow gives the upper Rhine its maximum flow in the summer, while winter rains in the middle and lower portions of the valley cause winter to be the season of high water in those sections. These two sources of supply, one reaching its maximum in the summer and the other in the winter, result in an unusually even flow of water throughout the year in all except the upper portions of the stream. The speed of the current is also studied, and it is pointed out that the rapid flow retards navigation in the portion of the river above Strasbourg. Ice hinders navigation during twenty days each year, on the average; and during exceptionally severe winters navigation may be stopped for considerable periods.

The depth of the channel varies widely in different parts of the river; but no complete charts exist showing depth, and so it is necessary to use pilots that know each part intimately. The various works in existence and under construction for the regulation of the flow and for flood prevention are of interest to those who are familiar with similar efforts to control American rivers.

The navigation of each section is related to the physical set-up, and the navigation of the tributaries is studied from the point of view of their contributions to the Rhine traffic. The discussion of the various types of boats used is somewhat technical, but the nationality of the Rhine fleet and of its personnel is of interest. The nationality of the fleet is as follows: German 45 per cent, Dutch 35 per cent, Belgian 12 per cent, French 7 per cent, and Swiss 2 per cent. The majority of the personnel is German, and the French boats are manned almost entirely by Germans.

In a brief economic survey the principal agricultural and industrial resources and activities of the valley are pointed out, and a detailed discussion is given of the Rhine ports having a yearly traffic of more than 1,000,000 tons. The importance of the Rhine to the maritime ports of Rotterdam, Antwerp, and Amsterdam is brought out. It is interesting to note that more than three quarters of the total traffic of Rotterdam goes to or comes from the Rhine territory.

The author concludes by emphasizing the major importance of the Rhine to Europe and the dependence upon it, from the point of view of navigation, of its bordering populations, pointing out that, from a human point of view, it is no longer a natural boundary but rather a unifying influence.

J. F. BOGARDUS

SOUTHERN GERMANY

ROBERT GRADMANN. **Süddeutschland,** Vol. 1: **Allgemeiner Teil.** x and 215 pp.; maps, diagrs., ills.; Vol. 2: **Die Einzelnen Landschaften.** vi and 553 pp.; maps, diagrs., ills., bibliogr., index. (Bibliothek Länderkundlicher Handbücher.) J. Engelhorns Nachf., Stuttgart, 1931. RM. 44. 9 x 6½ inches.

Professor Gradmann's work covering southern Germany represents the first in a series of regional handbooks that eventually will include all of Germany. The author is considered by Penck a master in the field of regional presentation and this work a model. In view of the importance attached to this outstanding work and its relationship to those that are to follow, perhaps the methodology should be given special consideration.

In Volume 1 the area as a whole is discussed and is followed in Volume 2 by its subdivision into natural regions, each of which is presented in detail. By first resorting to a general description and interpretation of the whole area, the author finds space in the discussion of the natural regions for considering aspects especially pertinent to the respective localities. Each natural region is treated systematically and in much the same way as the others but is given certain special turns in accordance with its particular problems. Such elements as location and origin of the name, morphology, occasionally the geology, climate and natural vegetation, agriculture, urban geography, followed by a general summary, in the main represent the mode of procedure.

The emphasis placed upon morphological problems raises a question as to the validity of such procedure in a geographical treatise. For example, on page 178 in the chapter on the region known as Neckarland we find a theoretical discussion of certain orogenic movements and their morphological significance. On page 183 special problems in valley development are discussed accompanied by a series of maps showing changes in drainage that have taken place in geological times. These are but two among many illustrations which might have been cited.

Is it the function of the geographer to engage in geological considerations? Should he not accept the conclusions of the geologists and confine himself to the surface

conditions? A geographer may well be versed in geological theory, but it seems as if such theory should not find a place in a geographical dissertation. By eliminating much space devoted to these matters, more attention could be directed to the life responses to the physical conditions of the regions. For example, in places the discussion of urban centers takes on an almost encyclopedic character with a minimum of geographic interpretation. These centers, representing in many respects the climax expression of the geographical unity of the regions, are deserving of more extended treatment.

The title of the volume, in a sense, justifies the inclusion of all material that appears therein. However, since the editor of the series presents the work as one representing the modern geographical viewpoint, we may well assume that it is intended as a work in the field of geography only and not in allied fields. There would be less objection to the detailed geological considerations if they were always associated with the economic, cultural, or other elements in the life of the region; but much of the material seems to be discussed merely for its own sake.

The above controversial aspect aside, the work is deserving of high commendation. It is a worthy contribution to the field of geography. When American geographers proceed to prepare greatly needed detailed regional studies of the United States, they will find such volumes as Gradmann's a source of numerous valuable suggestions.

The photographs are well selected and beautifully executed. The almost staggering bibliography containing 2285 titles is a mine of source material.

EUGENE VAN CLEEF

A NEW SWEDISH WORLD ATLAS

Svensk Världsatlas. 293 pp.; maps, diagrs., ills., index. Generalstabens Litografiska Anstalt, Stockholm, 1930. 9¾ x 6¾ inches.

The great Swedish firm of map and atlas makers, Generalstabens Litografiska Anstalt, celebrated its hundredth birthday by attempting to make an atlas of good, working-size maps that should yet be a volume small enough to stand on an ordinary bookshelf. Their success is surprising. The book stands but 9¾ inches high and contains 179 maps on scales as large or often larger than in the usual atlases of larger format. Compare it with Philips' Senior School Atlas, for instance, which stands two inches higher (11¾ x 10¼), too big for an ordinary bookcase shelf. The Swedish volume has the eastern United States and Canada on the scale 1:8,000,000, and from Philadelphia to Boston on 1:2,500,000, where Philips' best scale is 1:10,000,000. France, Germany, the Balkans, Italy, and Spain have the same scale in both books. Egypt and Russia are larger in the Swedish volume—1:8,000,000, with Philips 1:15,000,000. Parts of the British Empire are of course larger in the British work, those of Scandinavia larger in the Swedish work.

The maps of the Swedish atlas are admirable for their clearness and carry an excellent indication of relief. The colors and color combinations are the most pleasing that I know of in any current map work. Land boundaries (and country names) are shown in green, which does not interfere with the place names at all, and no small contribution to the clarity comes of omitting minor place names. What to omit is, of course, the cartographer's insoluble problem. Philips gets in, I should say, about as many names as his draughtsman can find place for. The Swedes have definitely maintained open spaces which make the names used much easier to see. If you want to find Vianna in the Portuguese department Beira, you will be glad Philips put it in; but if you only need Braga and Leixoes you will be glad the Swedes left Vianna out.

Large-scale insets, or part-page maps, are a feature of the book. No less than forty-five of these are on the scale of 1:1,000,000 showing the regions about each of the Scandinavian and Baltic cities, all of the greater cities of Europe, the fjeld

of Lapland, Iceland around Reykjavik, Danzig, Canton Bern, the Swiss Alps, Lake Geneva, the Strait of Messina, Cape Town, San Francisco, the Panama Canal—an extraordinary selection of plums from the millionth map of the world. For Asia, Africa, and South America the insert scales are somewhat smaller. There is a great group of city plans, 22 of them—the preface says 42!—all on the uniform scale 1:50,000, admirably clear, with street names so plain that notable spots like Washington Square in New York, the British Museum in London, the Invalides in Paris, and the Brandenburger Thor in Berlin can easily be found.

There are quite a number of the usual and some unusual world maps on a beautiful new base—a world in three thirds, each third extending from pole to pole and centered respectively on the 80th meridian west, the 40th and 160th east, dividing the land only in central and northern Asia.

A further novelty is a group of 92 excellent half-tone pictures illustrating landscapes, productions, transportation, and human affairs generally. They are new pictures and good ones, remarkably well chosen, 35 from Europe and 12 from other Mediterranean shores. There are 17 for North America, including an air view of the Panama Canal that gives a striking impression of the difference of level at the locks. They are not mere wonders of the world but for the most part pictures valuable for study and reference. Every fourth page in the book is beautifully printed text—descriptive matter and economic and historic data.

The book is a fine product of artist, engraver, and printer. A small defect to this reviewer's eye is the border of ruled lines used on the black and white maps to indicate water, which distracts from the details of the map. But the book is beautiful and useful, much handier than anything at all comparable that now exists, and full of material not easy to get at elsewhere. It should have an English dress!

MARK JEFFERSON

PYRENEAN STUDIES

HENRI CAVAILLÈS. **La vie pastorale et agricole dans les Pyrénées des Gaves, de l'Adour et des Nestes: Étude de géographie humaine.** 415 pp.; maps, ills., bibliogr. Armand Colin, Paris, 1931. 50 frs. 10 x 6½ inches.

HENRI CAVAILLÈS. **La transhumance pyrénéenne et la circulation des troupeaux dans les plaines de Gascogne.** 133 pp.; maps, bibliogr. Armand Colin, Paris, 1931. 15 frs. 10 x 6½ inches.

Henri Cavaillès of the Université de Toulouse is a long-time student of the Central Pyrenees. He has previously published certain significant studies of the geographical basis underlying the curious political federations existing between the two flanks of the range, notably the article, "Une fédération pyrénéenne sous l'ancien régime" (*Rev. Historique*, Vol. 105, 1910, pp. 1–69).

Now he has appeared in print in a single year with two publications of high geographic content. The more important is "La vie pastorale et agricole dans les Pyrénées des Gaves, de l'Adour et des Nestes." The study is characteristically French in its fine historical detail but is not characteristic of many French works in that it discusses no geology or physical circumstance that is not directly applicable to the thesis. It is geographic in the true sense from first to last. The book is a discussion first, of the milieu; secondly, of the historical-economic background; thirdly, of the present conditions. Lastly the various sections are taken as units. Each unit is discussed from the point of view of geographic landscape and the human responses. The reviewer has no little acquaintance with the regions and finds the book exhaustive and conclusive.

The second volume is a discussion of mountain and plain. Beginning with a definition of a term not widely understood in this country, transhumance, it proceeds to a separate discussion of the past and present herding conditions in the mountains

and in the plains. This includes maps and discussions of the routes of travel. Sheep found in summer on the crest of the Pyrenees spend winters in the valley of the Garonne even beyond Bordeaux.

RODERICK PEATTIE

SOME STUDIES IN ARGENTINIAN AGRICULTURE

THEODOR BRINKMANN. **Der Yerba Mate-Bau im argentinischen National Territorium Misiones als Grundlage bäuerlicher Siedlung.** Maps. *Berichte über Landwirtschaft*, Vol. 11 (N.S.), 1930, pp. 403–442.

THEODOR BRINKMANN. **Ackerbau und Kolonisation im argentinischen Chaco.** *Ibid.*, Vol. 12 (N.S.), 1930, pp. 499–540.

THEODOR BRINKMANN. **Entwicklungslinien und Entwicklungsmöglichkeiten der landwirtschaftlichen Erzeugung Argentiniens.** Maps, diagrs. *Ibid.*, Vol. 13 (N.S.), 1930, pp. 569–620.

Light is shed by these articles on important aspects of Argentine geography, though they are written in the field of agricultural economy and not of geography. Not only do they deal with the same subject matter and record factual material that geographers can use, but they develop clear regional concepts. Only the angle of view differs. The author focuses attention primarily on organization and economic structure of industry, instead of on cultural pattern spread in its natural setting. His interpretation is of statistical time-tables rather than of maps. The differences in point of view involve no implication of superiority or inferiority with reference to geography but represent a complementary contribution and suggest advantages in coöperation for scientific progress.

The article on the maté industry of Misiones characterizes well the regional individuality of this province with its moist subtropical climate and fertile forested hills, its neglected place in the development of the Argentine transportation pattern, and its vigorous colonization and specialization in maté planting. Overenthusiasm for maté is analyzed, disapproved, remedied, and withal nicely explained in relation to a great domestic maté market, natural advantages for production in competition with other Argentine regions, national advantages in competition with foreign forest regions, and a dearth of alternative opportunities. Even localization within the province is not overlooked—the accessible strip along the Paraná in contrast with the interior, the grassy southern tip in contrast with the forested mass.

In the article on agriculture in the Chaco Professor Brinkmann is less successful in characterizing the unity of the region, as it is concealed in the negative qualities that have distinguished it from its positively attractive neighbors. His reference to vegetation as a basis of unity is not supported by his discriminating subdivision of the region into three zones: the wet, forested, quebracho-yielding east, the dry savana cattle-and-corn-raising west, and the intermediate partly wooded cotton-raising center. In advice to present and warning to prospective inhabitants the author reveals plainly and well the negative qualities that make the Chaco a difficult and doubtful place of settlement.

The article on Argentine agricultural development in general is of less geographic import than the specific regional studies. Yet it may be noted that investigation here based on national statistics tends to the same conclusion as a geographic field study of a small district, namely that present land occupancy is characterized by instability due to richness of opportunity for alternative productive enterprises.

The three articles follow the pigeonhole-compendium form of organization and thereby increase their usefulness for reference purposes; and yet, strange to say, they do not lose their character as lively and interesting units of exposition. They bear the mark of well balanced and well expressed judgment based on dependable first-hand information.

ROBERT S. PLATT

The Swedish Arctic Ocean Expedition of 1929

J. W. Sandström: **Den svenska ishavsexpeditionen 1929.** Maps, diagrs., ills. *Ymer*, Vol. 50, 1930, pp. 75–117.

Earlier studies by Otto Pettersson, Wilhelm Meinardus, Nils Ekholm, and J. W. Sandström served as the direct incentives to the work of the carefully outfitted Swedish Arctic Ocean expedition of 1929. The important generalizations of these studies are given at the outset of the paper under review: that the position in the ocean where the Gulf Stream exerts its maximum warming influence is much farther north than is commonly supposed, i. e. just west of the Lofoten Islands, where the January temperature anomaly is approximately 27° C., and that from this center winter temperatures over Europe are affected in direct relation to wind directions. Thus westerly Lofoten winds produce warm weather in northern Europe and cold in southern Europe; southerly Lofoten winds produce cold weather on the continent of Europe and warm weather on the Atlantic.

The expedition, using a motor-equipped fishing sloop of fifty tons, spent two months in the Arctic Ocean. The first month was devoted to the Spitsbergen-East Greenland sector, the edge of the ice being followed west of Spitsbergen from latitude 81° N. to latitude 70° N., east of Scoresby Sound. The second month was devoted to the sector from North Cape to Novaya Zemlya and to Spitsbergen. The Gulf Stream was crossed four times in different places, its general characteristics were noted, and its temperature conditions studied in detail.

In July the Gulf Stream waters occupied about half the section from northern Norway to Greenland; westward the surface waters became markedly colder. Readings showed conclusively that the Gulf Stream was effective to depths greater than 100 meters. The thesis that the melting of the polar ice along its edge is an indirect result but a direct, primary cause of the existence of the Gulf Stream is defended.

The article closes with a concise discussion of the influence of the Gulf Stream on the weather of northwestern Europe. As a specific example the author points out that the exceptionally warm waters of the Gulf Stream, as studied in the summer of 1929, caused a long and persistent low pressure trough extending from Iceland to beyond North Cape during the autumn and early winter of 1929–1930, giving rise to persistent southerly winds over western Europe and an unusually mild winter in Sweden. A map of pressure and wind direction for January, 1930, adds to the effectiveness of the argument.

Nels A. Bengtson

Soils and Regionalism in the United States

Archer Butler Hulbert. **Soil: Its Influence on the History of the United States.** xiv and 227 pp.; maps, ills., index. Yale University Press, New Haven, 1930. $2.50. 9 x 6 inches.

Frederick Jackson Turner for a period of forty years has been the leader of a school of historians who have approached American history from a geographic viewpoint. In the United States there is a physical regionalism which has been a significant factor in the development of the political sectionalism of the historians. This sectionalism is based in a general way upon climate and more particularly upon physiography and soil character. It is the pedologic influences which Professor Hulbert essays to investigate and evaluate in this book.

The first seven of the twenty-one chapters constitute an introduction to the distinctly historical portion that follows. The first chapter, "The Basis of Provinces," and the second, "Climatic Influences on Man and Vegetation," present an elementary consideration of climate, geology, topography, and vegetation as they

affect soil character. In the third chapter, "The Waterway Keys to Our Soil Provinces," the author returns to a subject that has long engaged his attention. In turn he discusses "Some Aspects of River Control" and "Highland Pathways of Conquest and Migration," which treat of landscape features as factors in American expansion. In Chapter 6, entitled "The Story of Our Soils," the author indicates that he has read widely in the field of soil science, consulting many of the detail surveys of the Bureau of Soils. However, the reference to Coffey's Preliminary Soil Map of the United States" (1911) reveals that the recent developments in the classification of soils have not been studied critically. The seventh chapter, on "Soils and Migration," prepares the reader for the regional-historical problems that follow.

In "The Meadows of New England," followed by the "Call of the Connecticut," the author shows how important the choice soil areas were to the early settlers and how the Connecticut Valley with its lowland soils attracted settlers westward across the hills of eastern Massachusetts. Some of the other favored spots of New England are treated in the next chapter, "The Nipmuck and Chestnut Countries."

"The Tidewater Pioneers" knew the value of the sandy soils, which yielded a good crop of tobacco where topographic conditions were favorable. Across the fall line the pioneers emigrated to "The Virginia Piedmont," where the upland soils made their appeal to the serfs and others of humble circumstances.

In Pennsylvania the soil areas west of Philadelphia early attracted the settlers, and Lancaster County soon became distinguished as a prosperous agricultural region. The author has not neglected the human factors. He notes that many of the Scotch-Irish avoided the limestone areas, for they regarded them as barrens. Poor colonists could not afford to purchase farms in the fertile limestone areas, and the absence of springs was a deterrent to others.

To the westward the Shenandoah Valley attracted settlers and guided them southwestward toward the gaps that led them eventually into the fertile Nashville Basin and the blue grass region. The broad highland region was a rugged barrier, but in the valleys between the parallel ridges the author finds sufficient material for a chapter on "The Conquest of the Alleghenies." He refers to the region of folded mountains in Virginia, West Virginia, and Tennessee, giving a restricted regional connotation to the term Allegheny.

The student of soils will be pleased to find the pedologic element of the physical environment accorded an important place in this historical survey of American expansion. He will be disappointed to find that in a book of 227 pages the first seven chapters, nearly a third of the book, are introductory and that he does not get beyond the blue grass region until he has finished page 191. The next chapter, the last one in the book, is entitled "Types of Soil Influence in the West." Less than twenty pages are devoted to the Middle West and the West beyond. In the former lies one of the most productive agricultural regions of the world, and certainly he who would interpret the economic history of the United States should not pass so lightly across the region. The blackerths, prairyerths and gray-brownerths west of the Appalachian plateaus must be evaluated in the light of their productivity. Their capacity to produce agricultural commodities is so great that actual and potential overproduction has become one of the primary problems of government.

The specialists will find occasions for criticism in so far as the author tries to write in a field not peculiarly his own. For example, the geologist will hardly agree that "Most rocks, except limestone, expand and contract alike in all their parts" (p. 60). Also on page 43 the statement that the "serried, glaciated Alleghenies" give way near Cumberland to open parklike areas may be challenged by the physiographers. As a plea for the rewriting of local histories in terms of the significant elements of the natural environment the book is commendable, but as a comprehensive work, such as is indicated by the title, it is entirely too brief and incomplete.

GUY-HAROLD SMITH

Flood Control on the Mississippi

Arthur DeWitt Frank. **The Development of the Federal Program of Flood Control on the Mississippi River.** 269 pp.; index. (Columbia Univ. Studies in Hist., Econ., and Public Law, No. 323.) Columbia University Press, New York; P. S. King & Son, Ltd., London, 1930. $4.25. 9 x 6 inches.

Not the least of the problems connected with Mississippi floods has been the question of share of responsibility by the Federal government. From the beginnings of settlement on the lower Mississippi the flood plains were attractive because of the richness of the soils and the advantages offered in water transportation. As a navigable water the river proved adequate for the period, but its floodings were a great handicap as well as a serious menace to development. The best line of defense for riparian owners lay in the strengthening of the existing natural elevations. The first building of levees on record was near New Orleans in 1717. By 1735 levees extended twelve miles below and thirty miles above that city. Out of these humble beginnings have arisen a system of embankments and a multiplicity of problems almost incomprehensible to the average layman.

Federal interest in the Mississippi began with the introduction of the steamboat. To this end the first official survey of the lower river was made, which placed the main handicap to navigation on the lateral movements of water due to snags. The conclusion reached was that with a complete system of "dikes" these snags would "cease to accumulate," the currents would move straight on and thus keep the channel open. Here seems to have originated the idea of levee building as an aid to navigation, held to so tenaciously by army engineers in what has become known as "levees only" policy.

During the Civil War and Reconstruction periods flood control seems to have lost all that it had gained. In addition there happened to be a most remarkable series of major floods, 1858, 1859, 1862, 1865, 1874, 1882, and each found the levees in worse condition than the one before. In 1879 Congress created the Mississippi River Commission "to improve and give safety and ease to navigation thereof, prevent destructive floods, and promote and facilitate commerce, trade, and the postal service,"—the "prevent destructive floods" evidently meaning that improvements in navigation should not increase flood hazards.

During the succeeding period of Mississippi River Commission control the "levees only" policy has dominated. Aid given to flood control came only under the guise of directly or indirectly aiding navigation. The appropriation as late as 1916 was made "to improve navigation and promote the interests of commerce." In 1917 the Federal government for the first time avowedly went into levee building for flood control. It took the great disaster of the 1927 flood to bring about a recognition that the Mississippi flood problem was a matter of the general welfare. It aroused interest in Federal control, at its lowest since the Civil War and Reconstruction periods, as nothing else could have done. Plans of control were called for. Of the many schemes those of merit may be centered about the straightening of the river, the constructing of storage reservoirs, reforestation and afforestation, the building of levees higher and stronger, the constructing of special channels or spillways, and a combination of one or more of these. The greatest point of controversy, however, in the adoption of any kind of plan has lain in considering what part of the expenses of the program should be paid for by the Federal government. A board consisting of the Chief of Engineers, U. S. Army, the President of the Mississippi River Commission, and one civil engineer appointed by the president was created to adopt the best features of plans considered.

Changes already have been brought about since the publication of the book. In "Flood Control and Channel Maintenance on the Lower Mississippi River" (*Civil Engineering*, Vol. 1, 1931, pp. 815–820) General Lytle Brown, Chief of Engi-

neers, U. S. Army, outlines the present plan which provides protection by means of levees and controlled diversions, studies of detention reservoirs having so far proved disappointing and costly.

W. H. Haas

"The Incomparable Valley"

François E. Matthes. **Geologic History of the Yosemite Valley.** 137 pp.; maps, diagrs., ills., index. *U. S. Geol. Survey Professional Paper 160*, 1930. $1.10.

It rarely happens that a geologist, in studying and mapping a rugged area, uses an accurate topographic base prepared by himself. This distinction belongs to Mr. Matthes in the preparation of his monumental work describing "the incomparable valley." More than twenty years ago the Geological Survey issued his classic topographic map, which depicts faithfully and vividly the magnificent surface features of the Yosemite. It is fortunate that the man who, in the rôle of topographic engineer, became intimately acquainted with every cliff and dome in this fascinating area later assumed the task of unraveling the complicated geomorphic history of the region. Some of his important conclusions have been announced in papers published from time to time as the study progressed. All of these results, and much new material in addition, are brought together in the final publication. The text, written in a lucid style, is amplified and embellished by diagrams and by many artistic photographs.

After an adequate description of the valley and its surroundings, the author considers the development of the valley, which involves the history of the entire Sierra Nevada block. By an analytical geomorphic study, it is found that the cross profile of the valley has three distinct components, which represent as many principal stages in the evolution. At the top there are remnants of a broad, shallow valley, which probably was developed during a long interval preceding the late Miocene when the region was a hill country with subdued relief. Below this ancient surface are better-preserved remnants of a steeper-sided valley that appears to represent the vigorous uplift of late Miocene time and erosion to maturity during the Pliocene. Finally, at the bottom of the profile, there is the deep inner gorge that was cut in response to the last great tilting uplift in early Quaternary time. This gorge was cut by stream action but was profoundly modified by at least three stages of glaciation, which are differentiated by features of erosion and deposition. Some deepening of the main valley was accomplished by glacial erosion, but widening was a more important factor in producing the steep walls and the high falls at the mouths of tributaries.

By his convincing analysis the author disposes of the hypothesis, once seriously entertained, that faulting played a major rôle in forming this steep-walled valley. He also corrects a mistaken notion that glaciation was chiefly responsible for excavating the gorge. The discussion of the hanging valleys is especially illuminating. The great height of Yosemite Falls has been taken by some as a measure of the deepening accomplished by glacial erosion. Matthes shows that Yosemite Creek occupies an ancient valley, which has been cut very little below the old Miocene surface because the course of this valley is nearly parallel to the axis of tilting. Therefore the gradient of the tributary stream was not steepened by uplift, and it came to have a hanging character even during the Pliocene erosion cycle. This argument is clinched by the fact that other tributaries parallel to the axis of tilting and located below the reach of the Pleistocene glaciers also have a hanging relation to the parent valley.

One of the most interesting sections of the book deals with the extent of erosion and weathering since the various glaciations. Isolated pedestals of granite protected by erratic boulders since the first and second glacial stages afford a minimum measure of the thickness of rock removed in each interval. In one area that was glaciated during the second stage resistant dikes now project several feet above the enclosing

granite and add their testimony to that of the pedestals. Bed rock scoured by the last glaciation has lost only a part of its polished surface, whereas the rock surfaces affected by earlier glacial stages are not preserved except in a few favored localities, where till has formed a protecting cover. Development of great "domes" by exfoliation of thick concentric shells has required a long time. On unglaciated areas, such as the top of Half Dome, the shells are on a gigantic scale and the foliation reaches to considerable depth. Since the second glacial stage, "2000 centuries" ago, there has been moderate rounding off of angular edges by exfoliation, as exhibited on the Quarter Domes; but "the postglacial interval, which comprised only about 200 centuries, was too short, in many places, for the production of a single shell." Thus we have a roughly quantitative estimate of the rate at which this weathering process operates under the conditions of the Yosemite region.

In order to appreciate the geomorphic development of the Yosemite region the reader requires some knowledge of the varied bed rock and of the ancient geologic events recorded in structural features. This setting is supplied in a section of the paper entitled "The Sierra block"; but a more detailed discussion of the granitic rocks is given by F. C. Calkins in an appendix, which includes a geologic map. Thus the paper is a well-rounded treatise, of great value to the scientific student. At the same time it is an attractive and useful guide to the intelligent layman who visits the Yosemite.

CHESTER R. LONGWELL

RECENT GERMAN WORK IN ICELAND

HANS SPETHMANN, edit. **Deutsche Islandforschung 1930, Zweiter Band: Natur.** viii and 175 pp.; maps, diagrs., ills., bibliogrs. *Veröffentl. Schleswig-holsteinischen Universitätsgesell.*, No. 28, 2. Ferdinand Hirt, Breslau, 1930. 10 x 7 inches.

WOLFGANG OETTING. **Inselberge und Plateaus auf den Hochflächen Innerislands unter besonderer Berücksichtigung morphologischer Untersuchungen im Gebiet zwischen Hofs- und Langjökull.** Maps, ills., bibliogr. *Mitt. Geogr. Gesell. in München*, Vol. 23, 1930, pp. 1–52.

WOLFGANG OETTING. **Beobachtungen am Rande des Hofsjökull und Langjökull in Zentralisland.** Diagr., ills. *Zeitschr. für Gletscherkunde*, Vol. 18, 1930, pp. 43–51.

As an actively volcanic country still partially in the grip of a glacial period, lying in an intermediate geographic position between the Arctic and the Atlantic and between well settled Scandinavia and desolate Greenland, Iceland is an unusually attractive field for geographical study. To the earlier exploration of this field German investigators, Bunsen, von Waltershausen, and Keilhack, made important contributions; and since the appearance of Thorvaldur Thoroddsen's fundamental description (*Petermanns Mitt. Ergänzungsheft Nos. 152 and 153*, 1906) and geological map (1 : 600,000, Copenhagen, 1901) German geographers have also taken a leading part in the study of limited regions and specific problems.

The first-named volume is a collection of twelve papers dealing with various phases of the physical geography of Iceland. Heinrich Erkes' present contribution "Reëxplored Territory in the Interior of Iceland" is a vivid description of the great postglacial lava desert Ódáðahraun (3000 sq. km.) and the equally extensive highland drift waste Sprengisandur in central Iceland. Although it contains but few new observations this retrospective essay has considerable literary charm. A useful list of the author's publications on the interior of Iceland is appended.

Professor Hans Reck's paper on mass eruptions is an important contribution to the perplexing problem of the origin of basalt plateaus. Theoretically a mass eruption might occur at a point, at a line, or at a surface, giving respectively a central eruption, a fissure eruption, or an areal eruption. Central mass eruptions in Iceland

are represented by low, widespread lava domes named *Schildvulkan* in German and *Dyngja* in Icelandic. The lack of a single convincing, natural section through such a central vent in the early Kainozoic basalt plateau leads to the conclusion that central mass eruptions played no important part in the construction of the plateau. Mass eruptions from extended fissures are usually regarded as the most probable plateau-building mechanism; but, although recent eruptions of this type are known in Iceland, the absence of dikes passing into sheets in the plateau points to the absence or insignificance of this mode of eruption in the early Kainozoic. There remains the areal mass eruption, hitherto neglected as a plateau-building mechanism. In opposition to the views of Daly and of von Wolff, who regard an areal eruption as the result of an eruptive laccolith melting its way to the surface over a large area, Reck sees the action of typical areal eruptions in groups of irregularly arranged, nearly synchronously active craters connected with a common underlying magma body. Such crater groups are numerous in Iceland and in other volcanic countries. A plateau built by this action would show almost no trace of the mechanism; and thus among the most characteristic signs of the action of areal mass eruptions in basalt plateaus would be the very absence of evidence of the manner in which the lavas were erupted.

In 1927 and 1928 Dr. Oetting made a detailed study of the highland between Hofsjökull and Langjökull, two of the largest relics of the island ice in west-central Iceland. The full report, accompanied by new topographic and geological maps (1 : 200,000) covering an area of about 1130 square kilometers, appears in the second-named paper; a briefer account is given in the first volume under review, while some glaciological observations are contained in the last-named paper. The region is essentially a high (500–600 m.) plain of reworked drift partially overrun by recent lavas, from which rise a number of tabular inselbergs (900–1400 m.) built of volcanic breccia and capped by level lava sheets. In view of the similarity of structure of the several inselbergs and the striking accordance of the levels of the bases of their lava caps, Oetting concludes that they are simple erosion remnants of a once continuous plateau. Extending this conclusion to Iceland in general, Oetting suggests that block faulting has hitherto been given undue prominence in explanations of the topography of the great breccia formation.

Of the remaining papers of the Deutsche Islandforschung, space permits reference only to Johannes Georgi's account of meteorological work on the northwest coast of Iceland. Observations with pilot balloons from the northwest extremity of Iceland, less than 300 kilometers from the east coast of Greenland, disclosed long-sustained, swift southward movements of cold air bodies exceeding 10 kilometers in thickness. These cold blasts must strongly influence cyclonic conditions between Iceland, Greenland, and Ireland. According to Georgi the cold air bodies probably originate over the open sea between Norway, Spitsbergen, and Greenland rather than from the Greenland ice or from the polar basin. But in pursuing this problem Georgi believes, in partial agreement with Hobbs, that a strongly excentric pole of atmospheric circulation in the northern hemisphere may have to be taken into account.

M. A. PEACOCK

THE GREAT BARRIER REEF

C. M. YONGE. **A Year on the Great Barrier Reef: The Story of Corals and of the Greatest of their Creations.** xx and 246 pp.; maps, diagrs., ills., index. Putnam, London and New York, 1930. $6.00. 10 x 6½ inches.

In anticipation of four quarto volumes to be published by the British Museum and of others to be brought out in Australia, the leader of the biological section of the Great Barrier Reef Expedition, 1928–1929, tells "the story of corals and the greatest of their creations" in a manner that is edifying not only to the biologist

but to the geographer as well. The book contains somewhat detailed biological chapters on the nature and life of corals and entertaining accounts of other reef dwellers, such as the giant clam (*Tridacna*), "the largest bivalve mollusc of this or any other period of the world's history," a single pair of shells being known to weigh more than 500 pounds; or such as the microscopic brown algae that live in the coral polyps, more than 6000 having been counted in a single coral embryo of pinhead size. Very readable geographical chapters deal with the form and the visible features of the reefs, the conditions they offer for occupation, and their economic resources. A fuller geographical story will be told by members of the geographical section (compare J. A. Steers: The Queensland Coast and the Great Barrier Reefs, *Geogr. Journ.*, Vol. 74, 1929, pp. 232–257 and 341–370; and Michael Spender: Island-Reefs of the Queensland Coast, *Geogr. Journ.*, Vol. 76, 1930, pp. 193–214 and 273–297).

The object of the Great Barrier Reef Committee, which, formed in Queensland in 1922, later led to the organization of the Expedition in England under Yonge's leadership, was "the investigation of the origin, growth and natural resources" of the great reef. Perhaps for this reason, although the geological aspects of that investigation appear to have been assigned to the geographical section of the Expedition, Yonge devotes part of his first chapter to a brief exposition of several theories of reef formation. The exposition, however, is inadequate and uncritical and quite in contrast with the caution exhibited by him when writing on matters of biological theory, on protective mimicry for instance. He rashly states in connection with Daly's "fascinating" glacial-control theory that, during the glacial period, immense ice caps "covered the Poles" and extended "into what are now temperate regions."

In contrast with the care given to the description and illustration of biological facts of observation, the inferred consequences of Darwin's theory of upgrowing reefs on subsiding foundations are briefly stated and are illustrated only with antiquated vertical sections instead of with perspective views by which the consequences are so much better brought out. The false objection is quoted, probably from Geikie, that "in certain areas all three types of reefs occurred, while only one should have been present according to the Darwinian theory." It is confidently asserted that "many atolls may have been formed" very much as Murray's theory suggests, but no critical evidence to support that theory is presented; indeed, its explanation of barrier-reef lagoons by solution is discredited.

An inverted mental attitude, which implies that an investigation should begin with the most difficult aspect of its problems, is suggested when the author says he "can imagine no more appropriate starting-point for the story of corals and coral reefs" than the inscrutable Cocos-Keeling atoll, instead of an easily understood fringing reef or a close-set-barrier. "The inconceivably great amount of material needed to build up the sloping edge of the [Australian] continent into the form of a ledge in places almost 150 miles wide" is taken as excluding Darwin's theory for the Great Barrier Reef; and instead it is proposed that "before the land sank a broad coastal plain might have been formed by the accumulation of debris brought down by the rivers, the land then sinking and the coastal plain becoming a wide ledge running out from the coast and covered by a shallow sea," up from the floor of which the barrier reef might then grow. But this easy proposal includes no recognition of the manifest fact that the rivers would bring down just as much débris under Darwin's theory as under any other; no consideration of the postponement of reef formation until the imagined coastal plain should sink; no consideration of the difficulty involved in the advance of a widening alluvial plain into a sea where trade-wind breakers, an excellent description of which is given on later pages, beat violently and ceaselessly.

Again in contrast with the scrupulous care with which biological problems are treated is the omission from the brief mention of "sand" discovered in a recent

reef boring of all consideration of the rapid northward encroachment of the sands of Breaksea spit on the southern end of the Great Barrier and the associated extraordinary deepening of the sea floor thereabouts, as attested by reliable Admiralty soundings; for this short northward invasion of the sands since the recent submergence of the Queensland coast indicates very strongly that a much greater northward invasion took place during the long still-stand of the coast as indicated by littoral approach to peneplanation, before the recent submergence.

In the present reviewer's opinion the book would have been better if the discussion of coral-reef origins had been either omitted or made more critical. He has dwelt on the defects in this section; but it is subordinate to the main substance of the book which has a high value.

W. M. Davis

Climate for the "General Reader"

W. G. Kendrew. **Climate: A Treatise on the Principles of Weather and Climate.** xi and 329 pp.; maps, diagrs., ills.; index. Clarendon Press, Oxford, 1930. $5.00. 9 x 6 inches.

Karl Knoch. **Klima und Klimaschwankungen.** 151 pp.; maps, diagrs., bibliogr. (Wissenschaft und Bildung, 269.) Quelle & Meyer, Leipzig, 1930. RM. 1.80. 7 x 5 inches.

The name of W. G. Kendrew first became known in climatology in 1922, when "The Climates of the Continents" appeared. This was the first general English text on the climatography of the land areas of the world. In his new volume Kendrew has written a treatise "primarily for the general reader who wishes to know something of the principles of weather and climate." This more or less mythical person for whom so many books are written will find therein much of interest in connection with the phenomena of the atmosphere. Many strictly meteorological subjects are discussed, such as thermometers, barometers, rain gauges, sunshine recorders, etc.; barometric gradients; fogs; cyclones and anticyclones and their tracks; special winds (föhn, sirocco, bora, blizzard, etc.); types of British weather, and so on. There are also discussions of more strictly climatological matters, such as the chief régimes and regions of rainfall; the distribution of insolation and the effects of the atmosphere on insolation; the larger effects of land and water on climate; the characteristics of mountain and plateau climates; "some climatic types," etc. These varied topics are on the whole considered in an interesting way, and numerous illustrations, graphs, maps, diagrams, and some excellent half-tones add to the attractiveness of the book.

From the point of view of a teacher the situation is not quite so favorable. The meteorology and the climatology are intermingled in such a way that there is a certain lack of logical sequence. There is no general bibliography. A few footnote references are given in an incomplete form, e. g., "Climatic Cycles and Tree Growth"—Douglass (Washington); L. Hill, "Sunshine and Open Air." Acknowledgments are conspicuously absent. There are no subheadings under the general chapter headings. Many statements are so broad as to be somewhat misleading. In speaking of frost protection in California (p. 17) the author says that stoves are used and the smoke screen prevents frost damage. As a matter of fact, smoke screens have proved injurious to the fruit, and the oil burners now generally used give off a minimum of smoke. The lowest recorded temperature at Verkhoyansk is not −83° but several degrees lower. There are other statements to which exception may well be taken, such as that on page 40, "As the air heats its density becomes less, equilibrium becomes unstable and convection currents begin to carry the superheated surface air upwards, to be replaced by the air of the higher atmosphere which is at a normal temperature."

However, in spite of these drawbacks "Climate" will have a place on the shelves of the student of the atmosphere. The volume is additional evidence of the increasing interest in meteorology and climatology among English-speaking people and will doubtless further stimulate that interest.

Dr. Knoch, chief of the climatological division of the Prussian Meteorological Institute in Berlin, is the author of the chapters on the climates of South America in the new Köppen-Geiger "Handbuch der Klimatologie" (compare *Geogr. Rev.*, 21, 1931, pp. 527–528). The general plan of the present volume is more or less similar to that of two other recent pocket-size books on climate, C. E. P. Brooks's "The Weather: An Introduction to Climatology" (London, 1927) and K. C. Edwards' "The A B C of Climate" (London, 1930), and also of an earlier little volume, Eugen Alt's "Das Klima" (Leipzig, 1912). It is distinctly encouraging to note the growing interest in climatology which is evidenced by the publication of these three small-size books. Kendrew's recent "Climate" (see above) is another and much larger book on the same general field. As the author of "Klima und Klimaschwankungen" rightly remarks in his preface, it is a very difficult task to cover, within a small compass, the whole wide field of general and special climatology as well as of two other important subjects, changes of climate and climate and man. However, in so far as the task can be accomplished our author has done it with success.

The subdivisions of the text include the meaning, scope, and methods of climatological investigation (8 pages); elements of climate (38 pages); types of climate (3 pages); classifications of climate (6 pages); the climates of the world (44 pages); changes and oscillations of climate (26 pages); climate and man (19 pages). Most of the book follows the usual lines, and the treatment calls for no special comment. The section on changes of climate is an excellent presentation of this very controversial subject—a brief outline brought down to date. Under "climate and man" the controls of climate over habitability and civilization are hardly more than hinted at. Five pages are devoted to bioclimatology and to climatotherapy, and the last dozen pages concern the physical and psychical effects of climate and are largely based on the work of Hellpach and Berliner. One page of bibliographic references completes the volume. It is unfortunate that such a welcome little volume as this, which can be recommended to those who want a readable book on some of the fundamentals of climatology, should be printed in German type.

R. DeC. Ward

The Status of Oceanography

Henry B. Bigelow. **Oceanography: Its Scope, Problems, and Economic Importance.** vi and 263 pp., Houghton, Mifflin Co., Boston, 1931. $2.50. 8½ x 6 inches.

In a foreword to this volume, Dr. Frank R. Lillie states that "it is in no sense a textbook or a compendium of oceanographic knowledge" but "is an attempt to appraise the present condition of oceanographic research with reference to the more outstanding problems, so as to take bearings for future research." Such an appraisal is of special importance since oceanography has been forwarded very largely by specialists in other sciences who were working on problems that involved the sea—physicists, astronomers, geologists, meteorologists, biologists, and others. As a result, there has been no unified outlook on the problems of oceanography. This deficiency is supplied by Dr. Bigelow in the volume under review.

In the introductory chapter he quotes with approval the definition of oceanography "as the study of the world below the surface of the sea," adding that it should include also "the contact zone between sea and atmosphere." That gives oceanography a very extensive domain and makes of it, as the author puts it, "a mother science, the branches of which, though necessarily attacked by different disciplines,

are intertwined too closely to be torn apart." To give a rational exposition of the scope and present status of this inclusive science, the author adopts the method of discussing "certain of the underlying problems that seem most clearly to illustrate the general fields of research falling within the province of the oceanographer, and that are now most to the fore."

For convenience Dr. Bigelow divides the subject into three chief divisions—geological, physical-chemical, and biological. Taking up submarine geology first, he shows how far from satisfactory is our knowledge of submarine topography, submarine sedimentation, and submarine dynamic geology and how further knowledge in these fields will clarify our ideas in regard to such problems as the permanence of the ocean basins, the climates of the past, and the cycle of matter within the sea. In the next chapter, on the physical and chemical problems of the sea water, the problems discussed are grouped under the topics of temperature and salinity, circulation, penetration of radiant solar energy into the sea, and chemical problems of the sea. This is followed by a chapter on the relationship between oceanography and meteorology.

The three last chapters, constituting a little more than half the volume, are devoted, respectively, to life in the sea, the economic value of oceanographic investigations, and to the physical, chemical, geologic, and biologic unity in the sea. Life in the sea is discussed under the headings of oceanic zoölogy and botany, marine physiology, and marine bacteriology. And in directing attention to the fruitfulness of research on life in the sea, the author notes that it was "no accident that general physiology in America arose at the Marine Biological Laboratory at Woods Hole, or that the pioneer studies in artificial parthenogenesis, of balanced solutions, and so forth, were carried on at seaside laboratories, rather than inland."

In the consideration of the economic value of oceanographic investigations, Dr. Bigelow distinguishes between oceanic phenomena that exercise a basic control over the habitability of the land masses and those that man can control by his own efforts. Leaving the former out of consideration, the economic value of sea science is discussed with relation to the sea fisheries, navigational problems, soundings in connection with the laying of submarine cables, and seasonal weather forecasts. The last chapter is devoted to the exposition of the unity of oceanography. To quote the author, "until new vistas develop, our ventures in oceanography will be the most profitable if we regard the sea as dynamic, not as something static, and if we focus our attention on the cycle of life and energy there as a whole, instead of confining our individual outlook to one or another restricted phase, whether it be biologic, physical, chemical, or geologic."

The subject matter of this volume is part of a report submitted to the National Academy of Sciences by its Committee on Oceanography, Dr. Bigelow being secretary of the committee. That report, from the nature of the case, can appeal to a very limited public. By making this stimulating contribution available in the present form, Dr. Bigelow has made a much larger public his debtor.

H. A. MARMER

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